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CRYSTALLINE AND MOLECULAR FORCES.[1]

By Prof. JOHN TYNDALL, LL. D., F. R. S.

A FEW years ago I paid a visit to a large school in the country, and was asked by the principal to give a lesson to one of his classes. I agreed to do so, provided he would let me have the youngest boys in his school. To this he willingly assented; and, after casting about in my mind as to what could be said to the little fellows, I went to a village hard by and bought a quantity of sugar-candy. This was my only teaching apparatus. When the time for assembling the class had arrived I began by describing the way in which sugar-candy and other artificial crystals were formed, and tried to place vividly before their young minds the architectural process by which the crystals were built up. They listened to me with the most eager interest. I examined the crystal before them, and, when they found that in a certain direction it could be split into thin laminæ with shining surfaces of cleavage, their joy was at its height. They had no notion that the thing they had been crunching and sucking all their lives embraced so many hidden points of beauty. At the end of the lesson I emptied my pockets among the class, and permitted them to experiment upon the sugar-candy in the usual way.

When asked to come here and lend a helping hand in what I believe to be a truly good work (though hard pressed by other duties), I could not refuse the invitation.

I know not whether this great assembly will deem it an impertinence on my part if I seek to instruct them for an hour or so on the subject chosen for my little boys. In doing so I run the imminent risk of being wearisome as well as impertinent, while laboring under the further disadvantage of not being able to make matters pleasant at the conclusion of the lecture by the process adopted at the end of my lesson to the boys.

[1] A Lecture, delivered in the Free-Trade Hall, Manchester, on Wednesday, October 28, 1874.

We are to consider this evening the phenomena of crystallization; but, in order to trace out the genesis of the notions now entertained upon the subject, we have to go a long way back.

In the drawing of a bow, the darting of a javelin, the throwing of a stone, in the lifting of burdens, and in personal combats, even savage man became acquainted with the operation of *force*. His first efforts were directed toward securing food and shelter; but ages of discipline—during which his force was directed against Nature, against his prey, and against his fellow-man—taught him foresight. He laid by at the proper season stores of food, and thus obtained time to look about him, and become an observer and inquirer. He discovered two things, which now more specially interest us, and sent down to us the knowledge of his discovery. He found that a certain resin dropped from the amber-tree possessed, when rubbed, the power of drawing light bodies to itself, and of causing them to cling to it; and he also found that a particular kind of stone exerted a similar power over a particular kind of metal. I allude, of course, to the loadstone, or natural magnet, and its power to attract particles of iron. Previous experience had enabled our early inquirer to distinguish between a push and a pull. In fact, muscular efforts might be divided into pushes and pulls. Augmented experience showed him that in the case of the magnet, pulls and pushes—attractions and repulsions—were also exerted; and, by a kind of poetic transfer, he applied to things external to himself the conceptions derived from the exercise of his own muscular power. The pushes and pulls of the magnet and of the rubbed amber were to him also force.

In the time of the great Lord Bacon, the margin of these pushes and pulls was vastly extended by Dr. Gilbert, a man probably of firmer fibre, and of finer insight, than Bacon himself; who, moreover, was one of the earliest to enter upon that career of severe experimental research which has rendered our science almost as stable as the system of nature which it professes to explain. Gilbert proved that a multitude of other bodies, when rubbed, exerted the power which thousands of years previously had been observed in amber. In this way the notion of attraction and repulsion in external Nature was rendered familiar. It was a matter of experience that bodies between which no visible link or connection existed, possessed the power of acting upon each other; and the action came to be technically called "action at a distance."

But out of experience in science there always grows something finer than mere experience. Experience, in fact, only furnishes the soil for plants of higher growth; and this observation of action at a distance furnished material for speculation upon the largest of all problems. Bodies were observed to fall to the earth. Why should they do so? The earth was proved to roll round the sun; and the moon to roll round the earth. Why should they do so? What pre-

vents them from flying straight off into space? Supposing it to be ascertained that from a part of the earth's rocky crust a firmly-fixed and tightly-stretched chain started toward the sun, we might be inclined to conclude that the earth is held in its orbit by the chain—that the sun twirls the earth around him as a boy twirls a bullet at the end of a string round his head. "But why should the chain be needed?" asks the speculative mind. "It is a fact of experience that bodies can attract each other at a distance, and without the intervention of any chain. Why should not the sun and earth so attract each other? and why should not the fall of bodies from a height be the result of their attraction by the earth?" Here, then, we have one of those higher thoughts of speculation which grow out of the fruitful soil of observation. Having started with the savage and his sensations of muscular force, we pass on to the observation of force exerted between a magnet and rubbed amber, and the bodies which they attract, and rise by an unbroken growth of ideas to a conception of the force by which sun and planets are held together.

This idea of attraction between sun and planets had become a familiar one in the time of Newton. He set himself to examine the attraction, and here, as elsewhere, we find the speculative mind falling back for its materials upon experience. It had been observed, in the case of magnetic and electric bodies, that the nearer they were brought together the stronger was the force exerted between them; while, by increasing the distance, the force diminished until it became insensible. Hence the inference that the assumed pull between the earth and the sun would be influenced by their distance asunder. Guesses had been made as to the exact manner in which the force varied with the distance; but, in the case of Newton, the guess was supplemented by being brought to the severe test of experiment and calculation. Comparing the pull of the earth upon a body close to its surface, with its pull upon the moon, 240,000 miles away, Newton rigidly established the law of variation with the distance, thus placing in our hands a principle which enables us to determine the date of astronomical events in the far historic past or in the distant future.

But, on his way to this great result, Newton found room in his ample mind for other conceptions, some of which, indeed, constituted the necessary stepping-stones to his result. The one which here concerns us most is this: Newton proved that not only did the sun attract the earth, and the earth attract the sun, *as a whole*, but that every particle of the sun attracts every particle of the earth, and the reverse. His conclusion was, that the attraction of the masses was simply the sum of the attractions of their constituent particles.

This result seems so obvious that you will perhaps wonder at my dwelling upon it; but it really marks a turning-point in our notions of force. You have probably heard of late of certain disturbers of the public peace named Democritus, Epicurus, and Lucretius. These

men adopted, developed, and diffused the dangerous doctrine of atoms and molecules which found its consummation in this city of Manchester at the hands of the immortal John Dalton. Now, the grand old pagans whom I have named, and their followers up to the time of Newton, had pictured their atoms as falling and flying through space, hitting each other, and clinging together by imaginary claws and hooks. They entirely missed the central idea that the atoms and molecules could come together, not by being fortuitously knocked against each other, but by their own mutual attractions. This is one of the great steps taken by Newton. He familiarized the world with the conception of *molecular force.*

But the matter does not end here; experience had given us the key to further mysteries. In the case of electricity and magnetism a double exercise of force had been observed—repulsion had been always seen to accompany attraction. Electricity and magnetism were examples of what are called *polar forces;* and, in the case of magnetism, experience itself pushed the mind irresistibly beyond the bounds of experience, compelling it to conclude that the polarity of the magnet was resident in its molecules. I hold a strip of steel by its centre, between my finger and thumb. One half of the strip attracts, and the other half repels the north end of a magnetic needle. I break the strip in the middle, and what occurs? The middle point or equator of the magnetism has shifted to the centre of the new strip. This half, which a moment ago attracted throughout its entire length the north pole of a magnetic needle, is now divided into two new halves, one of which wholly attracts, and the other of which wholly repels, the north pole of the needle. Thus the half when broken off proves to be as perfect a magnet as the whole. You may break this half, and go on breaking till further breaking becomes impossible through the very smallness of the fragments; still you find at the end that the smallest fragment is endowed with two poles, and is, therefore, a perfect magnet. But you cannot stop here: you *imagine* where you cannot *experiment;* and reach the conclusion entertained by all scientific men, that the magnet which you can see and feel is an assemblage of molecular magnets which you cannot see and feel, but which must be intellectually discerned.

I shall endeavor to show you some of the actions of this polar force, at the same time asking you to remember that my main object here to-night is to show you the growth of scientific ideas, and to illustrate the manner in which the scientific investigator uses his thoughts and his hands in the investigation of Nature.

Scientific ideas, as already stated, spring out of experience, but they extend beyond the boundary of experience. And, indeed, in this power of ideal extension consists for the most part the differences between scientific men. The man who cannot break the bounds of experience, but holds on to the region of sensible facts, may be an ex-

cellent observer, but he is no philosopher, and can never reach those principles which bind the facts of science together. True, the speculative faculty may be abused like all good things, but it is not men of science that are most likely to abuse it. When he accounted for the heat of chemical combination by referring it to the clash of atoms *falling* together, a townsman of your own described an image presented to his mind but entirely beyond the reach of his senses. It was, however, an image out of which grew memorable consequences; among others this one of a personal nature: The walls of this Free-Trade Hall, or rather its predecessor, have rung with the speeches of Cobden, and Bright, and Wilson. But, at the time when their words rolled round the world, a scientific worker was silently and studiously engaged in your city grappling with the problem how out of heat is extracted mechanical force, and by implication with far higher problems. He grappled with it successfully, bringing it into the full light of experimental demonstration. And I venture to affirm that in the coming time, not even the great orators and politicians just named, not even the greatest of your manufacturing princes, will enjoy a purer, a more permanent or enviable fame—there is not a man among them of whom Manchester will be more justly proud than of her modest brewer, but renowned scientific worker, James Prescott Joule.

You will pardon this momentary deflection from my subject. We have now to track still further the growth of our notions of force. We have learned that magnetism is a polar force; and experience also hints that a force of this kind may exert a certain structural power. It is known, for example, that iron-filings strewed round a magnet arrange themselves in definite lines, called, by some, "magnetic curves," and, by Faraday, "lines of magnetic force." In these observed results of magnetic polarity we find the material for speculation, in an apparently distant field. You can readily make an experiment or two for yourselves with any magnet. My excellent assistant, Mr. Cottrell, places two magnets before me, and over them a sheet of paper. Scattering iron-filings over the paper and tapping it, the filings arrange themselves in a singular manner. There is a polar force here in action, and every particle of iron on the paper responds to that polar force, and the consequence is, a certain structural arrangement—if I may use the term—of the iron-filings. Here is a fact of experience which, as you will see immediately, furnishes further material for the mind to operate upon, rendering it possible to attain intellectual repose and satisfaction while speculating upon apparently remote phenomena.

You cannot enter a quarry and scrutinize the texture of the rocks without seeing that it is not perfectly homogeneous. If the quarry be of granite, you find the rocks to be an agglomeration of crystals, of quartz, mica, and felspar. If the rocks be sedimentary, you find them, for the most part, composed of crystalline particles derived from older rocks. If the quarry be marble, you find the fracture of the rocks to

be what is called crystalline fracture. These crystals are, in fact, everywhere. If you break a sugar-loaf, you find the surface of fracture to be composed of small, shining, crystalline surfaces. In the fracture of cast-iron you notice the same thing; and next to his great object of squeezing out the entangled gas from his molten metal, another object of your celebrated townsman, Sir Joseph Whitworth, when he subsequently kneads his masses of white-hot iron as if they were so much dough, is to abolish this crystalline structure. The shining surfaces observed in the case of crystalline fracture are surfaces of weak cohesion; and, when you come to examine large and well-developed crystals, you soon learn why they are so. I try the crystal of sugar referred to at the beginning of this lecture in various directions with the edge of my knife, and find it obdurate; but I at length come upon a direction in which it splits clearly before the knife, revealing two shining surfaces of cleavage. Such surfaces are seen when you break cast-iron, and the metal is strengthened by their abolition. Other crystals split far more easily than the sugar.

In the course of scientific investigation, then, as I have tried to impress upon you, we make continual incursions from a physical world where we observe facts, into a super or sub-physical world, where the facts elude all observation, and we are thrown back upon the picturing power of the mind. By the agreement or disagreement of our picture with subsequent observation, it must stand or fall. If it represent a reality, it abides with us; if not, it fades like an unfixed photograph in the presence of subsequent light. Let me illustrate this. You know how very easy it is to cleave slate-rock. You know that Snowdon, Honister Crag, and other hills of Wales and Cumberland, may be thus cloven from crown to base. How was the cleavage produced? By simple bedding or stratification, you may answer. But the answer would not be correct; for, as Henslow and Sedgwick showed, the cleavage often cuts the bedding at a high angle. Well, here, as in other cases, the mind, endeavoring to find a cause, passed from the world of fact to the world of imagination, and it was assumed that slaty cleavage, like crystalline cleavage, was produced by polar forces. And, indeed, an interesting experiment of Mr. Justice Grove could be called upon to support this view. I have here, in a cylinder with glass ends, a fine magnetic mud, consisting of small particles of oxide of iron suspended in water. You can render those suspended particles polar by sending round the cylinder an electric current; and their subsequent action may be rendered evident. At present they are promiscuously strewed in the liquid. But the moment the current passes they all set their lengths parallel to a common direction. Before the current passes, the strongest beam of light can hardly struggle through the turbid medium. But, the moment it passes, light is seen to flash out upon the screen. Now, if you imagine the mud of slate-rocks to have been thus acted on, so as to place its particles with

their lengths in a common direction, such elongated and flat particles would, when solidified, certainly produce a cleavage.

Plausible as this is, it is not the proper explanation, the cleavage of the slate-rocks being demonstrably not crystalline, but, as shown by Sharpe, Sorby, Haughton, and myself, due to pressure.

The outward forms of these crystals are various and beautiful. A quartz-crystal, for example, is a six-sided prism, capped at each end by six-sided pyramids. Rock-salt, with which your neighbors in Cheshire are so well acquainted, crystallizes in cubes; and it can be cloven into cubes until you cease to be able to cleave further for the very smallness of the masses. Rock-salt is thus proved to have three planes of cleavage at right angles to each other. Iceland spar has also three planes of cleavage, but they are oblique instead of rectangular, the crystal being, therefore, a rhomb instead of a cube. Various crystals, moreover, cleave with different facilities in different directions. A plane of principal cleavage exists in these crystals, and is accompanied by other planes, sometimes of equal, sometimes of unequal value as regards ease of cleavage. Heavy spar, for example, cleaves into prisms, with a rhombus or diamond-shaped figure for a base. It cleaves with greatest ease across the axis of the prism, the other two cleavages having equal values in this respect. Selenite cleaves with extreme facility in one direction, and with unequal facilities in two other directions.

Looking at these beautiful edifices and their internal structure, the pondering mind has submitted to it the question, How have these crystals been built up? What is the origin of this crystalline architecture? Without crossing the boundary of experience, we can make no attempt to answer this question. We have obtained clear conceptions of polar force; we know that polar force may be resident in the molecules or smallest particles of matter—we know that by the play of this force structural arrangement is possible. What, in relation to our present question, is the natural action of a mind furnished with this knowledge? Why, it is compelled by its bias toward unity of principle to transcend experience, and endow the atoms and molecules of which these crystals are built with definite poles, whence issue attractions and repulsions for other poles. In virtue of this attraction and repulsion some poles are drawn together, some retreat from each other; atom is thus added to atom, and molecule to molecule, not boisterously or fortuitously, but silently and symmetrically, and in accordance with laws more rigid than those which guide a human builder when he places his bricks and stones together. From this play of invisible particles we see finally growing up before our eyes these exquisite structures, to which we give the name of crystals.

In the specimens hitherto placed before you the work of the atomic architect has been completed; but you shall see him at work. In the first place, however, I will take one of his most familiar edifices, and

try to pull it to pieces before your eyes. For this purpose I choose ordinary ice, which is our commonest crystalline body. The agent to be employed in taking down the molecules of the ice is a beam of heat. Sent skillfully through the crystal, the beam selects certain points for attack; round about those points it works silently, taking down the crystalline edifice, and reducing to the freedom of liquidity molecules which had been previously locked in a firm, solid embrace. The liquefied spaces are rendered visible by strong illumination, and throwing their magnified images on a screen. Starting from numerous points in the ice we have expanding flowers, each with six petals, growing larger and larger, and assuming, as they do so, beautifully crimped borders; showing, if I might use such terms, the pains, and skill, and exquisite sense of the beautiful, displayed by Nature in the formation of a common block of ice.

Here we have a process of demolition, which, however, clearly reveals the reverse process of erection. I wish, however, to show you the molecules in the act of following their architectural instincts, and building themselves together. You know how alum, and nitre, and sugar crystals, are formed. The substance to be crystallized is dissolved in a liquid, and the liquid is permitted to evaporate. The solution soon becomes supersaturated, for none of the solid is carried away by evaporation; and then the molecules, no longer able to enjoy the freedom of liquidity, close together and form crystals. My object now is to make this process rapid enough to enable you to see it, and still not too rapid to be followed by the eye. For this purpose a powerful solar microscope and an intense source of light are needed. They are both here. Pouring over a clean plate of glass a solution of sal-ammonia, and placing the glass on its edge, the excess of the liquid flows away, but a film clings to the glass. The beam employed to illuminate this film hastens its evaporation, and brings it rapidly into a state of supersaturation; and now you see the orderly progress of the crystallization over the entire screen. You may produce something similar to this if you breathe upon the frost-ferns which overspread your window-panes in the winter, and permit the liquid to recrystallize. It runs, as if alive, into the most beautiful forms.

In this case the crystallizing force is hampered by the adhesion of the liquid to the glass; nevertheless, the play of power is strikingly beautiful. In the next example our liquid will not be so much troubled by its adhesion, for we shall liberate our atoms at a distance from the surface of the glass. Sending an electric current through water, we decompose the liquid, and the bubbles of the constituent gases rise before your eyes. Sending the same current through a solution of acetate of lead, the lead is liberated, and its free atoms build themselves together to crystals of marvelous beauty. They grow before you like sprouting ferns, exhibiting forms as wonderful as if they had been produced by the play of vitality itself. I have seen these things

hundreds of times, but I never look at them without wonder. And, if you allow me a moment's diversion, I would say that I have stood in the spring-time and looked upon the sprouting foliage, the grass, and the flowers, and the general joy of opening life; and in my ignorance of it all I have asked myself whether there is no power, being, or thing, in the universe whose knowledge of that of which I am so ignorant is greater than mine. I have asked myself, Can it be possible that man's knowledge is the greatest knowledge—that man's life is the highest life? My friends, the profession of that atheism with which I am sometimes so lightly charged would, in my case, be an impossible answer to this question: only slightly preferable to that fierce and distorted theism which I have had lately reason to know still reigns rampant in some minds as the survival of a more ferocious age.

Everywhere throughout our planet we notice this tendency of the ultimate particles of matter to run into symmetric forms. The very molecules seem instinct with a desire for union and growth. How far does this play of molecular power depend? Does it give us the movement of the sap in trees? Assuredly it does. Does it give us, in ourselves, the warmth of the body and the circulation of the blood, and all that thereon depend? We are here upon the edge of a battle-field which I do not intend to enter to-night; from which, indeed, I have just escaped bespattered and begrimed, but without much loss of heart or hope. It only remains for me to briefly indicate the positions of the opposing hosts. From the processes of crystallization which you have just seen, you pass by almost imperceptible gradations to the lowest vegetable organisms, and from these through higher ones up to the highest. The opposition to which I have referred is: that whereas one class of thinkers regard the observed advance from the crystalline through the vegetable and animal worlds as an unbroken process of natural growth, thus grasping the world, inorganic and organic, as one vast and indissolubly connected whole, the other class suppose that the passage from the inorganic to the organic required a distinct creative act, and that to produce the different forms, both in the world of fossils and in the world of living things, creative acts were also needed. If you look abroad you will find men of equal honesty, earnestness, and intelligence, taking opposite sides as regards this question. Which are right and which are wrong is, I submit, a problem for reasonable and grave discussion, and not for anger and hard names. The question cannot be solved—it cannot even be shelved—by angry abuse. Nor can it be solved by appeals to hopes and fears—to what we lose or gain here or hereafter by joining the one or the other side. The bribe of eternity itself, were it possible to offer it, could not prevent the human mind from closing with the truth. Skepticism is at the root of our fears. I mean that skepticism which holds that human nature, being essentially corrupt and vile, will go

to ruin if the props of our conventional theology are not maintained. When I see an able, and in many respects courageous man, running to and fro upon the earth, and wringing his hands over the threatened loss of his ideals, I feel disposed to exhort him to cast out this skepticism, and to believe undoubtingly that in the mind of man we have the substratum of all ideals. We have there capacity which will as surely and infallibly respond to the utterances of a really living soul as string responds to string when the proper note is sounded. It is the function of the teacher of humanity to call forth this resonance of the human heart, and the possibility of doing so depends wholly and solely upon the fact that the conditions for its production are already there.

EVOLUTION IN ORNAMENT.

By CH. FRED. HARTT.

ON the two Morgan Expeditions to the Amazonas, in 1870 and 1871, there was obtained from a burial-mound on the island of Marajó, or Johannes, a lot of ancient pottery, consisting of burial-urns, idols, utensils of various kinds, personal ornaments, etc., many of which were richly ornamented with *grecques*, and scrolled borders of a very high order of development. The resemblance borne by some of these ornaments to Old-World classic forms was very striking, and certain borders were, even in their accessories, identical with similar ornaments in Etruscan art. It has already been pointed out by Owen Jones that the so-called Greek fret has a very wide distribution, occurring not only in Egyptian and Greek art, but in that of India and China, while, in the New World, it was cultivated widely in both Americas. The distribution of these simple ornamental forms among widely-separated savage tribes renders it extremely unlikely that they should have all been derived from a common source, and their independent origin is all the more probable, since it has been conclusively shown that identical myths, religious ideas, manners and customs, found in different parts of the earth, have often originated independently of one another. Yet, while it is quite easy to understand how pottery might be invented by two different tribes, how is it possible that the same series of ornamental forms should arise among several independent and disconnected peoples? To the solution of this question I have addressed myself, and in this paper I propose to give, in a very condensed form, some of the more important results of my studies.[1]

[1] In my volume on the "Antiquities of Brazil," now nearly ready for the press, I shall, in connection with an analysis of the ornaments of the Marajó pottery, treat of this subject much more thoroughly.

Purely æsthetic decorative art has had its origin in the attempt to please the eye by lines and colors, just as music has originated in the attempt to give pleasure to the ear by a rhythmic series of sounds. Imitative decorative art appeals to the understanding as well as to the feelings; it is a song with words, but mere æsthetic ornament is visible music without words, and it is to this latter division of ornament that I shall principally invite your attention.

Color and form in ornament are so very different in their functions that they must be considered apart. Of the two, form is the more important element, and, in the following discussion, color will be left out of consideration.

The secret of the pleasant effect produced upon us by beautiful lines is, I believe, to be found in the structure of the eye itself, and I shall attempt to show that a line is beautiful, not because of any inherent quality of its own, but, primarily, because of the pleasure we take in making the muscular movements necessary to run over it with the eye, though, through education, we may afterward come to recognize, at a glance, and get the full effect of a form that has once given us pleasure; just as in music, the first few notes of an *aria* may be sufficient to recall the general effect of the complete composition.

When I look out of my window, the image of a very large tract falls upon my retina. I see at once a multitude of houses, and the infinitude of objects that go to make up the picture, and apparently I see every thing distinctly, but this is really far from being the case. If I look suddenly out at a landscape that I have never seen before, and fix my gaze upon a church-spire for a few moments, the image of the landscape falls immovably upon the retina; but, if I now suddenly withdraw and try to reproduce by sketch or writing what I have seen, I shall find myself totally unable. I have only an indistinct impression of the church-spire and perhaps of a few prominent objects in its immediate vicinity. I have *seen* the landscape, but I have not *observed* it.[1] Now let me return, paper in hand, to sketch the same landscape. Instead of fixing my eye immovably upon one point, I deliberately run it over the leading lines of the view, and then trace lines upon the paper that produce the same effect upon my eye as those in Nature have done. My sketch will at best be imperfect, but its accuracy will be in proportion to the care with which I have examined the outlines in the landscape. In observing an object, we do not then look fixedly at it—*we run the eye* over it. Let us see what this means.

The retina is not in all parts equally sensitive to light, and the whole of a visual image is not distinctly perceived at once. Directly in the back part of the eye is a little spot, about a line in diameter,

[1] Observation consists in the deliberate and careful running of the eye over the features of an object so that they are distinctly seen and appreciated. It is an art only to be learned by long practice. In natural-history studies I have found drawing to be a great aid in training a student, as it affords him a test of the accuracy of his observation.

called the yellow spot of Sömmering, and to this distinct vision is limited, for we see clearly only the part of an image that falls within it. It is even doubtful whether we see at one time distinctly, or, in other words, can *observe*, more than a point in that image. If you look at the middle of this page, you really see clearly only the point directly before your eye. The rest is indistinct, and, to observe a word on another part of the page, you must move the eye so that its image may fall on the yellow spot. So in reading, you run the eye over the words, or, by moving the eye, cause their images to fall successively upon the yellow spot, and, that you may do so readily, the words are arranged in straight, horizontal lines. The eyeball, otherwise immovable, may be rotated in its socket by the action of muscles, of which, in each eye, there are four principal ones, arranged in pairs, as in Fig. 1. When *A* contracts, the pupil is turned in the direction *B A*. The pair *B A* then cause the eye to rotate from side to side, while the pair *C D* cause it to rotate in a vertical plane. By combining two contiguous muscles, as, for instance, *A* and *C*, we may move the eye obliquely in any direction. Of the oblique muscles represented in the diagram I will not here speak, as they are apparently not so important in observation as those just described.

FIG. 1.

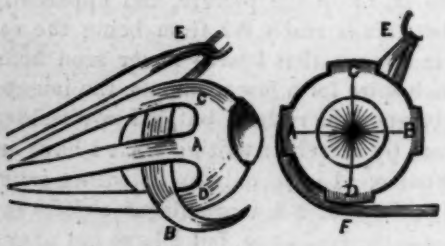
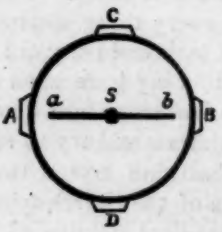


FIG. 2.



If I look at the middle of a straight, horizontal line, my head being held erect, the image of that line (*a b*, Fig. 2) will lie on the retina directly between the muscles *A B*, the central point falling in the middle of the yellow spot *S*. In running my eye over that line, I use the muscles *A B* in such a way as to draw the image through the yellow spot; and, if, in doing so, I use these muscles with perfect regularity, I say the line is straight. Perpendicular and horizontal straight lines are the more easy to examine, because their images fall directly between two opposing muscles. An oblique line is difficult to examine, and we instinctively turn the head, in order to bring it in the plane of rotation of one or the other set of muscles. In following a curved line with the eye, two muscles are used together, one contracting more rapidly than the other. A curve is therefore more difficult to observe, or run the eye over, than a straight line, and the diffi-

culty increases with the subtileness of the curvature.[1] The æsthetic effect of curves, as of gestures, is appreciated only after long training. Their beauty is primarily due to the pleasure we take in making the muscular movements necessary to follow them, and this pleasure is strictly akin to that which we feel in tracing them with the hand, either upon paper, or simply in gesture. Pleasure-giving, graceful, muscular movements are always in curves, and their grace depends upon the subtileness of the curve.

If decorative art has had a beginning and an evolution, we should expect to find a progress from straight lines to circles, spirals, and ellipses, while more subtile curves, such as we find in Nature, would be adopted later, and this is the case, not only in the art-history of nations, but also in that of individuals, for the child must be educated not only to make, but to appreciate and enjoy beautiful lines.[2]

Man, the world over, seeks to give pleasure to the eye. He is not satisfied that an object should be useful to him; it must be at the same time beautiful; and indeed he is usually quite as anxious that it should look well, as that it should minister to his comfort. It is not enough that clothing should be warm: it must be graceful in form, and covered, more or less, with ornament. A house of logs would hold a congregation and supply all the facilities for public worship, but that is not enough. We strive to make it a palace, and enrich its walls with beautiful forms. It is verily surprising what an important element ornament is in life. Is it, then, wonderful that man, striving everywhere to please the same eye by lines, should occasionally invent, independently, similar ornamental forms, or that decorative art should, in its beginning, evolve in the same direction in different countries?

The class of ornaments I have studied with the greatest care, and, at the same time, the greatest success, is that to which the so-called "Greek fret" and "honeysuckle ornament" belong, and I now propose to discuss the question of the origin and evolution of these decorative forms, premising that other classes of ornaments may be studied in exactly the same way.

If a single straight line is pleasant to the eye, two parallel straight lines are still more so; for, in running the eye over one of the lines, we have a sort of accompaniment produced by the indistinctly-seen second line; or, in looking along an imaginary line between the two,

[1] A straight line is beautiful, because of the pleasure we derive from the perfectly even, regular use of the muscles employed in following it with the eye, a pleasure comparable to that produced by passing the hand over a smooth, flat surface, or by listening to a single musical note.

[2] In music we find also a progress from a monotonous series of effects, to those which may be represented by more and more subtile sounds. These are the curves of *melody*, of *force*, and of *acceleration*, all of which, in the evolution of music, tend to greater subtilty. I suppose that this progress from monotony to subtilty is to be explained by the unconscious desire to escape the fatigue produced by a series of too similar effects.

we get the indistinct effect of both; but it must be observed that the lines must neither be too near together, nor too far apart, else the effect of the parallelism is either impaired or entirely destroyed. The whole surface of an object, as, for instance, of a vase, may be ornamented by a great number of parallel lines, and this is often the case in primitive or rude art; but, with culture, comes the tendency to draw more or less narrow bands of lines following the most important lines of the object.

A further step is taken in the attempt to make two parallel lines more agreeable to the eye by filling in the space between them with lines, drawn in various directions, and it is in this way that the frets have originated. By drawing equidistant parallel lines directly across between the two main lines, as in Fig. 3, we make a series. This, as

FIG. 3.

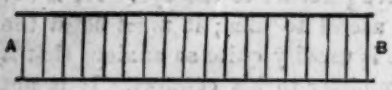
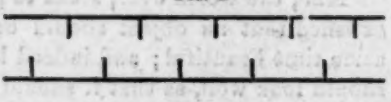


FIG. 4.



it exists in the drawing, is a series in *space*, but, as it grows up under the hand, or is examined by the eye, it is a series in *time;* and, in looking from *A* to *B*, an effect is produced upon the eye analogous to that produced upon the ear by the repetition of a musical note, with the same interval.[1] If lines be drawn only part way across, from each side alternately, as in Fig. 4, we have a sort of rhythm produced. If the lines all reach the centre, they may be, and often are, even in very savage art, connected together by twos, as in Fig. 5. This produces a series of units, each one of which is pleasant to examine with the

FIG. 5.

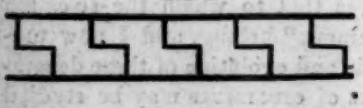


FIG. 6.

eye. This is the simplest form of the fret. If the lines are drawn not quite to the centre, they may be united by oblique lines, as in Fig. 6, *A*, and lines drawn past the centre may be connected in the same way, as in *C*, but neither of the resulting units is very agreeable to the eye, and such attempts are characteristic, either of a rude stage

[1] Irregularity in the interval interrupts the æsthetic effect. As each unit in the series falls on the yellow spot and is distinctly perceived, an effect is produced upon the brain which has a certain duration, gradually fading away. If the units are separated by the same intervals, these æsthetic effects will be alike; but, if they follow one another irregularly, the effect produced will be irregular, unexpected, and consequently disagreeable. The lengthening or diminution of the intervals, according to certain laws, heightens the æsthetic effect by relief from monotony; and this appears to be the least of the pleasure we derive from gradation in tint or shade.

of art, or of the work of a bungler. When the lines are not drawn to the centre, they may be joined as in *B*, and this form of fret was much cultivated in America; but it is objectionable, apparently on account of the obliquity of the units, and it is vastly inferior to the fret, Fig. 7, *A*, where lines, drawn past the middle, are united in a similar way. This last is the true Greek fret, though it occurs also in

Fig. 7.

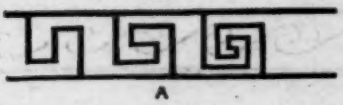
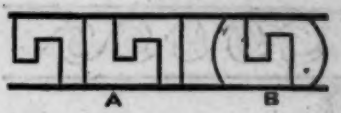


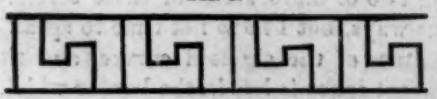
Fig. 8.



American aboriginal art. The units may be made more or less involved, as in Fig. 7, but the simple forms are the more pleasing.

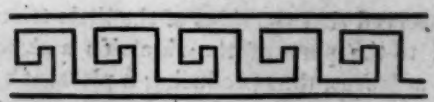
I have observed that in Brazil, and elsewhere in America, the artist has often taken care to separate the units in this fret from one another, either by drawing lines between them, as in Fig. 8, *A*, or by placing them in cartouches, *B*. The addition of the line in *A* enhances the beauty of the series by breaking up the monotony and introducing a pleasing alternation. The attempt to separate the units resulted, however, in bringing about their firm union; for it was ob-

Fig. 9.



served that, by obliterating the dotted spaces in Fig. 9, the whole series could be drawn without lifting the hand, and thus arose the current fret, Fig. 10. Examples of the modification of ornaments by obliteration of parts, in this way, are common, not only in aboriginal, but also in classic and modern civilized art. The bounding lines, Fig. 10, were afterward added, and greatly heighten the beauty of

Fig. 10.



the border. The current fret is not only agreeable to run the eye over, but it is pleasant to trace with the hand. Current frets may of course be more or less involved.

Unless care is taken in drawing a current fret, one is apt to round down the angles, and, in running the eye over this ornament, there is a tendency not to follow lines down to the angles, but to swerve from one line to another, avoiding the corners—the muscular movements

of the eye being such as would be necessary to follow a curve. It was soon found that frets drawn, probably at first unintentionally, with rounded corners, were pleasant to examine with the eye, and afterward they were purposely rounded down, giving rise to the beautiful linked scrolls, Fig. 11. At first, the most important part of this ornamental border was the scroll, and the connecting curve was

FIG. 11.

FIG. 12.

treated, so to speak, as a mere hair-line; but, by-and-by, the eye began to take more and more pleasure in following this more subtile connecting line, and it came finally to be cultivated, to the neglect of the scrolls, giving rise to the sigmoids, Fig. 12.

Some have claimed that this last ornament was originally emblematic of water. This was certainly not the case, and it never came to mean water until, having fully grown, it was recognized as resembling the curling waves of the sea. In Etruscan art we frequently find a series of little dolphins gracefully leaping over the crests, or fishes are drawn in below. Here, undoubtedly, the ornament was treated as representing water, or the sea. A host of beautiful borders grew up by combining two or more series of these scrolls and shading the spaces in various ways, but I have not time to speak of them here.

With the culture of the sigmoid curves, and the neglect of the spirals, much vacant space is left in the border which will look better if filled in with ornament.[1]

In Brazil I have found little triangles drawn in these spaces, as in Fig. 13, while exactly the same border is found in Etruscan art.

FIG. 13.

FIG. 14.

It will be observed that the sides of the little triangles are approximately parallel to the parts of the sigmoids and bounding lines to which they are adjacent, thus producing a pleasant effect on the eye. The next step in the evolution of this border consists in uniting the little triangles with the sigmoids, as in Fig. 14, and this form I have observed on a Peruvian vase.

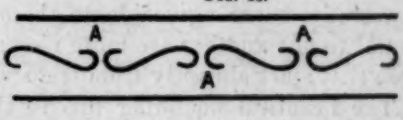
With progress in culture comes the love of variety and change. Savage music, savage art, every thing in fact in uncivilized life, is monotonous. An Amazonian Indian will listen enrapt for hours to

[1] Some writers say that a space *demands* ornament, but the demand is subjective, not objective.

the repetition of the same monotonous song, which produces on civilized ears only increasing torture. The fret is at first drawn with all its unity running in the same direction, but in course of time it is found that a change of direction not only relieves the eye but gives greater pleasure, and the series comes to be broken up into bars, alternating in direction. This is observable not only in the classic Greek frets, but also in similar ornaments in America. In the intervals between the bars a square figure is often introduced, and this, both in Greek and South-American art, sometimes contains a cross or a quatrefoil. Similar breaks were often introduced into the scroll-border, in which case the bars were separated by a figure, shaped more or less like a cross-section of a biconcave lens, Fig. 15, *A*.

FIG. 15.

FIG. 16.



In Old-World decorative art the great step was taken when the sigmoids were separated and alternately reversed, as in Fig. 16. This gave an opportunity for the growth between the sigmoids, of accessory ornaments that developed into an infinitude of beautiful forms in Egyptian and Greek art. It will be observed that, in this series, the little volutions, Fig. 16, *A*, *A*, *A*, are turned alternately up and down. The accessory ornament corresponding to Fig. 15, *A*, has therefore a broad base upon which to expand on one side and a narrow one on the other. These accessory ornaments may be developed on both sides of the line of sigmoids, but in this case a double series is formed, and a single one is more effective.[1] In Greek art they were principally cultivated on the upper side, giving rise to a single series of alternately broad and narrow figures supported on a line of sigmoids, as in Fig. 17. I would therefore claim that the upright, so-called

FIG. 17.

[1] This border is more effective when used horizontally. Vertical ornamented series are very often bilateral, and much wider than horizontal borders. Where a fret or honeysuckle border runs completely round the side of a room, we shall find that the horizontal parts give more pleasure to the eye.

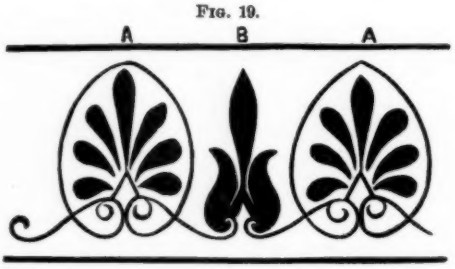
honeysuckle ornament or Anthemium was developed from the accessory ornament *A*, Fig. 15, while the oblique honeysuckle ornament, Fig. 18, appears to have been developed from the little triangles, Fig. 13.

FIG. 18.

In the Greek honeysuckle ornament the lines are not only subtile and beautiful, but they flow from one another and the parent-stems tangentially, according to a recognized and readily-explainable law in decorative art. For, just as gestures that flow tangentially from one another are more agreeable to the muscles of the arm, so lines tangential to one another are more pleasant to follow with the eye than those that start abruptly from one another.

The beautiful bounding line to the figure *A*, Fig. 19, appears to have been added after attention had been attracted to the elegant outlines of the Anthemium. When the figures *A*, *A*, were drawn close together, but little space was left for the narrow figure *B*, which was

FIG. 19.



therefore compressed as in Fig. 17. As the ornaments *A* and *B* were cultivated, the sigmoids were neglected, and, in course of time, they dropped out entirely from some of the borders, leaving, however, at the base of the ornament, two little volutes, which it is important to note are in the broad figure *A* turned in a direction opposed to that of the generating volutes. These little basal volutes are most remarkably persistent, and serve to aid us in determining the origin of many decorative forms, that have changed to such an extent, that their relation to the Anthemium would otherwise not have been suspected. Time will not allow me to trace out at greater length the line of evolution of this series of ornaments, and I can only allude to the Acanthus border as its richest and most luxuriant outgrowth. This is a matter of history, and I do not need to discuss it here.[1]

[1] The "egg and tongue" or "egg and arrow" border had originated from the honeysuckle border, in architecture, in the attempt to produce, by a narrow cornice, the gen-

Decorative art has developed through the constant attempt to please the eye by more and more beautiful forms, and in obedience to the law of *the survival of the most beautiful or of the fittest to please;* for pure, well-constructed forms are persistent, while those that are abnormal, *bizarre*, or not adapted to the eye, die out. We still, to-day, use straight lines and frets, and a multitude of beautiful forms, many of which, doubtless, have come down to us from an immense antiquity. They are normally beautiful and we shall always need them. These, I may add, are also the forms which we shall find most widely distributed.

The connection between the manufacture of pottery and the evolution of ornament is exceedingly close; and some of the most beautiful ornamental borders, etc., have originated on pottery, the soft, easily-scratched clay furnishing an excellent surface for drawing upon. In savage America the manufacture of pottery falls everywhere to the lot of women, since, as it is a branch of cooking, she, having the charge of domestic affairs, naturally makes the vessels in which to prepare food. But the Indian woman not only makes the pottery, she also ornaments it. Elsewhere, as among certain tribes in Africa, and also among the Papuans and the Feejees, woman is the ceramic artist. Llewellyn Jewett thinks that the Celtic burial-urns were made and ornamented by women. But, the world over, woman, among savage tribes, not only makes ornamented pottery, but she spins and weaves, and makes and decorates clothes. She is, in fact, the primitive decorative artist. Even in civilized life she still loves to cover with beautiful, purely æsthetic forms every thing her hand touches, and it is through her influence, more than through that of man, that decorative art flourishes to-day. I do not know whether her greater susceptibility to the influence of decorative art-forms springs from her greater delicacy of physical organization, or whether, what is perhaps more probable, it is owing to the wants of an entirely different life from that which man leads.

Ornament is something so necessary to civilized life, so universally necessary, that, like music and the other fine arts, it merits serious and intelligent study. A song is evanescent, but a good ornament "is a joy forever." To-day, in our craving, we cover every thing about us with a motley mixture of classic and detestably rude forms, and half even of the educated really do not know how to distinguish a good ornament from a bad one. Ornamental art will never take its proper rank, and be fully appreciated, until it is, in the first place, systematically studied, and, in the second place, intelligently and widely taught.

eral effect of the latter border when seen at a distance. Ruskin cannot see what arrows have to do with eggs, and, though he admits the border to be beautiful, he characterizes it as a "nonsense" ornament.

THE FUTURE OF CHEMISTRY.

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EVERY science seems to have, as a science, its most rapid and brilliant growth during the earlier portions of its history. By this I do not intend to say that the mere bulk of its material increases more swiftly than at a later period, when the number of its students and investigators has become great. I mean simply that important generalizations are more readily made and more frequent, and that abstract conceptions are more speedily fertile in results. The reason for this is very obvious. At first, when any new science has but just assumed definite shape, every student has it before his mind as a unit. All parts of the field are immediately under his eye; no portion of it can easily escape notice. Thus it is studied, not less in its details, but more as a definite, consistent whole; and its growth is consistent, well-balanced, and harmonious. When, however, the field becomes larger, there is a splitting up into specialties, and, in general, each specialty is cultivated by some assiduous worker who cares but little for the character which the science may take in its entirety. In other words, the greater the mass of scientific material, the greater is the tendency among investigators to study details at the expense of generalities. Accordingly, the details multiply and become unmanageable; complexity increases, and symmetrical development comes comparatively to a stand-still.

This is emphatically true of chemistry at the present day. Only a very few chemists now study their science as a grand unit. We have technical chemists, agricultural chemists, analytical chemists, physiological chemists, and so on. Each one devotes himself to his specialty almost without reference to the others. What relation his particular branch may bear to the complete science is hardly thought of. Such questions are left to speculators and dreamers. Among those who study the abstract science, without reference to its practical applications, it is much the same. One man has all he can do to examine the derivatives of a single organic group. If he can obtain fifty new compounds in which the interlinking of the atoms may be represented in some unheard-of way, his ambition is satisfied. He chlorinates this body, and deoxidizes that; he makes numberless substitutions, all of which he knew beforehand to be possible; but what, in the end, does it amount to? In Germany, where nine-tenths of the chemists seem to be running wild over the so-called "aromatic group," this multiplication of new bodies is going on with unparalleled rapidity. And yet not one in five hundred of the substances discovered gets thoroughly described. This naphthaline derivative is a solid,

with a certain odor, color, melting-point, and crystalline form; and there the description ends. No thought of ascertaining its other physical properties ever seems to enter the head of the discoverer. Doubtless all this work has a value; some of it has already led to results of great importance; still it is not in any such direction that chemistry is to look for its chief future growth. The same amount of effort, otherwise expended, would yield much richer returns. Unfortunately, an inferior line of research has become fashionable, and scientific investigators, like all other people, are more or less subject to fashion. It must be plain to every one, however, that the work of chemistry amounts to a good deal more than merely to obtain, formulate, and classify new compounds. It is necessary to study not only the bodies themselves, but also the laws involved in their formation and decay. We should seek to understand what physical forces are operative in each reaction, and in what quantities. No chemical change can occur unattended by the phenomena of either heat, light, or electricity. To-day, little is done save to investigate the *results* of chemical reactions. Surely the phenomena of the reactions themselves ought to be studied a little more. Chemistry would not lose much were no new compounds to be described for ten years to come, if chemists might only be induced to examine more closely the substances already known.

These few words of well-meant criticism may very properly lead us to the main subject of this paper: What is the future of chemistry? In what direction must the science look for its grandest development? What grand generalizations may we expect, and what steps should be taken to lead up to them? As the past is always prophetic of the future, it is evident that we must pay some attention to the former growth of chemistry before we can safely predict what is to come. If we would be thorough, we ought to do even more, and extend our view across the limits of this particular science into the fields of other sciences closely connected with it. For present purposes, however, we need consider, in conjunction with chemistry, only its twin-sister, physics. The two sciences are so closely intertwined that neither can be studied alone. Progress in either, in the long-run, means progress in both. Upon the border-land between the two our attention must be fixed.

Upon studying the history of chemistry, we cannot but be struck by the changes which have occurred both in the form and in the significance of chemical notation. There we have to deal with a symbolism so peculiar that it represents in its modern form several very important stages of scientific growth. Every great change in chemical thought is mirrored by some modification in this symbolic system. At first a formula represented the composition by weight of a substance, and embodied certain theoretical conceptions with which we have, for present purposes, nothing to do. Soon an extension of our

knowledge so modified the notation of chemistry that the new formulæ, though differing but slightly from the old, represented more than composition by weight, namely, composition by volume also. Still later came the attempt, now being vigorously continued, to make every formula represent not only ultimate composition by weight and by volume, but also the probable arrangement of the atoms within the molecule. In other words, if we ignore the atomic hypothesis, a modern chemical formula aims to express some of the more important chemical relations and reactions of the body represented. In close connection with these purely chemical discoveries, we find a little physical work. Thanks to Kopp, we are able to calculate from the formula of almost any liquid its atomic volume, and thence its specific gravity at the boiling-point. Other investigators enable us to calculate the indices of refraction for different liquids, and, to a more limited extent, some other physical properties also. In short, a system of notation, originally based upon the properties of the atoms as regards weight, has been found to express also many of their other physical relations; and the list of facts thus expressed is continually lengthening. Evidently, then, the tendency of chemical investigation is to connect the physical properties of every substance directly with its composition.

Here we step over the border into physics. Plainly, if we have to deal with physical properties, we must study the forces represented by them. And, fortunately for the chemist, the tendency among physicists is entirely in his favor. Growing up contemporaneously with the development of chemical notation, we have had the grand ideas of the conservation of energy and the correlation of forces. We have learned that force is one, indestructible and uncreatable, and that all its manifestations are mutually convertible one into another. Either of the great modes of force may be active in affecting chemical composition; may cause chemical union or chemical separation; may be the motive of either analysis or synthesis. Now, in the direction here suggested, the main work of physics is being done. The chief object of the physicist to-day is to determine quantitatively the relations connecting all the different varieties of energy. Under what circumstances, and how, are forces transformed? Since these transformations are differently effected through the intervention of different forms of matter, it is clear that the physicist must take into account the chemical composition of the materials with which he deals. In short, then, the chemist must look to physics for a knowledge of the forces involved in chemical changes; while, on the other hand, the science of physics must needs throw from chemistry its information upon the nature of all the material agencies through which the transformations of force become apparent. Neither physics nor chemistry can work independently of the other; the more closely they become allied in the labor of investigation, the more rapidly will both progress. The

two lines of research converge more and more day by day; in the end they will unite and become one.

To sum up our reasonable expectations, we may hope that before long the chemist, from the composition of any substance, will be able to calculate all of its physical properties — boiling-point, melting-point, specific heat at every temperature, expansibility, density, index of refraction, conductivity for heat and for electricity, and so on to the end. I, for one, do not doubt that the day when this will be possible is approaching more rapidly than the majority of chemists suppose. Until that time arrives chemistry cannot claim the honor of being an exact science. In physics a result is to be accomplished which will be complementary to this. Given the quantitative relations of the forces, we ought to be able, from the properties of any body as regards one force, to compute its properties with regard to all others. Knowing the thermal relations of any substance, for example, we shall eventually be able to calculate at once its optical, electrical, and magnetic properties. These results, to be achieved by physics, can be brought about only in connection with the chemical investigations which this paper is intended to emphasize.

But the future of chemistry does not end with the completion of the researches which we have thus far considered. It is the glory of science that every great achievement only opens the way for still greater achievements lying far beyond. So, when chemistry shall have reached the splendid future which I have ventured to suggest, it will only find itself possessed of materials with which to start for a grander future far away in the dim distance. We may expect that an exact knowledge of the laws governing the physical properties of substances will enable us to foresee just what compounds are possible, and by what reactions they may be obtained. Throughout the science, accurate calculation will be substituted for much abortive experiment, and both time and labor will be saved. The same lines of investigation, prolonged still further, will settle the much-vexed question of the nature of the elements; so that we may hope to know whether they are all but varieties of one or two, or whether they are many and essentially dissimilar. Upon the same experimental basis the truth or falsity of the great atomic theory may rest. Given the knowledge which we may expect to have concerning the physical relations of substance, and we ought to be able to devise many crucial tests for the idea of the atomic constitution of matter. All the great speculative questions of modern chemistry must be eventually fought out upon the battle-field of physics.

Now, having recognized some facts concerning the intellectual future of chemistry, let us inquire what material steps will best lead up to them. What experimental work is most needed to begin with? Plainly, if we are to discover laws connecting the physical properties of compounds with their composition, we must first determine the

physical properties of the elements. This work should be done with the greatest care and thoroughness. Every element should have its relations to the forces of Nature thoroughly fixed and tabulated. Even the rarest elements ought not to be neglected, since each one has its scientific importance, fills a place in some series or groups, and, for purposes of generalization, is of as great interest as any other. But, as it is to-day, the commonest substances have been very imperfectly studied. Only a few constants have been determined for some of the most familiar elements, the gases especially. Just enough is known about the commoner metals to show us how ignorant we really are. Here, then, is a great field for work, and in it some of the richest materials for both chemistry and physics are to be gathered. It is, indeed, strange that this work, obviously of such vast importance, should have been so long postponed. Of course no single individual could undertake it, but it seems as if some learned society, or even some government, might assume the burden. A twentieth part of the money expended for the determination of one astronomical constant, the earth's distance from the sun, ought to cover all the expenses of the undertaking. If we had in America a laboratory exclusively devoted to research, suitably manned and equipped, our country might carry off the glory of achieving this grand work. In default of such a laboratory, however, the labor might be accomplished through the cooperation of many individual workers, each one doing his small part, not aimlessly, but in unison with the others. One chemist might undertake to furnish certain of the elements in a perfectly pure condition; another might carefully determine under varying circumstances their densities and rates of expansion; a third could work up their specific and latent heats; a fourth their electrical relations, and so on. Failure to attain grand results would be impossible. Doubtless the labor would prove irksome and monotonous, but the reward would be sure. In five years, more would be done toward rendering chemistry an exact science, than can be accomplished in a century by means of the chemical investigations at present most in vogue.

The physical properties of the elements being established, the next thing is to do somewhat similar work for compounds. And here, before entering on experimental labors, it is necessary to know what has already been done. This knowledge is at present difficult to obtain, since the materials are scattered through many pages of many volumes of scientific transactions and periodicals, and need to be collected and systematically arranged. This work of tabulation having been finished, chemists will be able to see distinctly where experiment is most needed, what must be done entirely new, and what ought to be done over again. Then, some of the experimental details might be easily intrusted by professors to the hands of students. If, for practice, a student is taking specific gravities, let him work upon substances for which that constant has never been determined. So also with such

other physical measurements as naturally come up in a college laboratory. The student would be getting his instruction at the same time that he felt himself interested in aiding science, and both he and science would be gainers. The material so collected might hardly be of the highest accuracy, but it would certainly not be quite without scientific value. Any one, who will examine the nature of the material already on hand, will forcibly realize this fact.

It would be easy to multiply suggestions. Any chemist, who will carefully survey the field, will be surprised at the immense amount of obviously important work which has hitherto been left undone, and which should take precedence of nearly all the chemical investigations now most in fashion. The necessity of this work is based upon no wild speculations, but upon a foundation of the most severely practical ideas. No extraordinary difficulties hedge it about, no real impracticabilities stand in the way. Certain great laws ought to be discovered, and they can be discovered only by means of researches such as are here suggested. A few years of steady, earnest work upon the part of fifty scientific chemists would accomplish all the chief results which I have ventured to prophesy.

CONCERNING BEARS.

By WILLIAM E. SIMMONS, Jr.

THE bear family (*Ursidæ*), though comprising a comparatively small number of species, is yet one of the most wide-spread of all the carnivora, being found all over the earth's surface, except in Africa and Australia. In the latter country, there is an animal somewhat resembling the bear in appearance, and having the tree-climbing habit, known popularly as the Australian bear. This animal is, however, not a bear, but belongs, with its cousins, the kangaroo, bandicoot, and opossum, to another family. Regarding the existence of the bear in Africa, there has long been some difference of opinion. Herodotus, Virgil, and other ancient writers, speak of Libyan bears. Pliny alludes to Numidian bears being exhibited by Ethiopian hunters in a Roman circus, 61 B. C. Latterly, Ehrenberg and Forskal both mention a black plantigrade animal, called by the natives *karvai*, which inhabits the mountains of Abyssinia. They hunted and saw it, but failed to capture a specimen. It is possible that the bear may yet be found in at least a portion of the vast unexplored area of that continent, but the opinion that it does not exist there is now generally held by naturalists, and it may reasonably be entertained, until controverted by the finding of a specimen.

The general characteristics of the bear are the rough, shaggy coat

conspicuous massiveness of the hinder parts, which gives a peculiar shape to the body; plantigrade gait, and the habit of erecting the body and standing upon the hind-feet when attacked or in combat. The feet, especially the paws, are armed with long, sharp claws, not retractile, nor so much crooked as are those of the feline tribe, nevertheless capable of inflicting terrible wounds when impelled by the powerful force which the bear can exert. The bear is both carnivorous and vegetarian, and will apparently thrive on either a purely animal or vegetable diet. It is a gregarious animal, extremely sociable, subject to strong attachments for its mate and young, and, in a state of domestication, for man. Most of the species are good climbers, and all are good swimmers. Excepting a few species, it is a singularly harmless animal while undisturbed, but is ferocious and dangerous when attacked, or when defending its young. Its sagacity, strength, and surprising tenacity of life, render it a formidable combatant. It is remarkably adroit in guarding itself against the blows of an antagonist, and will ward off even the heaviest with wonderful dexterity. In combat, it rears upon the hind-feet and strikes powerfully with its paws; it also endeavers to crush the body of its antagonist by hugging, and will at the same time inflict fearful wounds with the claws of its hind-feet. Although so ferocious when aroused to anger, it is (excepting the polar and the grizzly) easily domesticated, and makes a most affectionate and amusing pet. One of the most curious characteristics of the bear is its habit of hibernating through the winter. During the autumn it becomes very fat, and, about the end of October, completing its winter house, ceases feeding for the year. A remarkable phenomenon then takes place in the animal's digestive organs. The stomach, no longer supplied with food, contracts into a very small space. A mechanical obstruction called the "tappen," composed of fine leaves, or other extraneous substances, blocks the alimentary canal, and prevents the outward passage of any matter. The bear continues in its den until the middle of April, in a dull, lethargic condition. If discovered and killed at any time in this period, it is found to be as fat as at the beginning. It is said, however, that, if it loses the "tappen" before the end of its hibernation, it immediately becomes extremely thin. During the hibernation the bear gains a new skin upon the balls of its feet, and, during the same time also, the female brings forth her young, from two to four in number. The latter act occurs generally from the middle of January to the middle of February. The pairing season occurs in the summer, from June to September. The period of gestation is about seven months, and the newly-born cubs are scarcely larger than puppies.

The visitor to Central Park, who walks along the corridor east of the Museum building, cannot fail to be struck with the grizzly bear (*Ursus horribilis*, or *U. ferox*). His mixed brownish and steely-gray coat, great size, massive proportions, and, above all, his ferocious as-

pect, render him one of the most conspicuous objects there. Observe his great broad head, with the small, cruel, brown eye, pointed muzzle, and powerful jaws, which, opening occasionally, display a set of alarming teeth. His fore-limbs, by their size indicating enormous strength, are each armed with five claws from four to five inches long, nearly straight. These claws are not needle-pointed like the cat's, but come to an edge like a chisel, and they are extremely sharp. His hind-limbs

Fig. 1.—Grizzly Bear (*Ursus horribilis*).

are even more massive still, and are also armed with similar though shorter and more curved claws. His tail is so short that it is hidden by his coat. All this time he has been contemptuously eying us from the back part of his cage, but now he has become impatient of our scrutiny, and suddenly reaches toward us with open mouth, uttering a savage sound between a sigh and a growl. He then turns to gallop around his cage, and affords an opportunity to observe one of his most striking peculiarities. This is his curious, shambling gait. His fore-limbs go in a canter, while his head sways from side to side, and the rest of his body slides along upon the soles of his hind-feet. Mr. Darwin would be sure to call this sliding movement an inherited peculiarity, acquired by the grizzly's ancestors in sliding down the glaciated sides of the Rocky Mountains. He has it, whatever may have been the manner of its coming to him, and constant practice of it has worn the floor of his cage white and smooth. The grizzly is the largest member of his family; a full-grown male being from eight and a half to nine feet long, and the girth of the body is equal to the length. The average weight is about 800 pounds. The one we have been regarding is a fine specimen, being between seven and eight feet long. The color is not uniform, being in some cases of a dull brown, in others almost black, and in still others

almost white. The head is covered with short, brown hair; the ears are short, and the depression between the brow and the muzzle considerable. The head is much larger in proportion to the size of the body than in other bears; and its feet, also, with the single exception of the polar bear, in which there obtains a still larger proportion. His haunts are the Rocky Mountains and the plains eastward; he is also commonly found westward, and as far north as latitude 61°. His principal food is flesh; but fruits and other vegetable substances also form a part of his diet. The younger animals are tree-climbing, but the older are not, seemingly, from their great weight. The pregnant female and the young animals hibernate, but the full-grown males are as active in winter as at other seasons.

The grizzly is the most ferocious and terrible of all American animals. He exercises absolute terrorism over every living creature that comes in his way. It is said that even the hungry wolf will flee at the sight of his track, and no animal will venture to touch a deer that has been killed and left by him. His strength is such that, even the powerful bison falls an easy prey, and a single blow from one of his paws has been known to remove the entire scalp from a man's head. He is the only member of his family that will venture to attack man unchallenged, but it is said that he will retreat at the scent of a man, if he can do so unobserved. He has attributed to him a peculiar habit, of digging a pit for his fallen prey, in which he covers it over

FIG. 2.—BLACK BEAR (*Ursus Americanus*).

with leaves and rubbish. Hunters, knowing this habit, have saved their lives in desperate cases by feigning death without wounding the bear, escape being made while the latter is continuing his ramble in search of other prey. He is so tenacious of life that, unless shot through the heart or brain, his body may be riddled with bullets without fatal effect. One which had received two bullets through his heart, besides eight in other parts of his body, survived more than twenty minutes, and swam half a mile. The grizzly is not easily tamed unless captured at a very tender age, but even then he is rough in habits and dangerous as a pet.

Next to the grizzly's cage is that of the black bear (*Ursus Americanus*). It contains several animals of both sexes. One of the males is a very fine specimen, being about the maximum size of his species, five and six feet in length. His coat is a glossy black, the hairs being much shorter than those of his neighbor. On his cheek the hair assumes a brownish hue. His head is much smaller in proportion to his body than is the grizzly's, it is also narrower, and shows a more decided convexity of facial outline. The muzzle is longer and narrower in proportion to the size of the head. The limbs are far less massive and proportionally longer, the feet smaller, and the claws decidedly shorter and more crooked. His eyes, too, are larger, and he has, instead of the savage, rather a mild and good-humored aspect. In keeping with his appearance, he displays a decided disposition to be sociable, and readily puts his nose through the bars to receive fragments of cake or other delicacies that are offered him by the children. Vegetable substances constitute his principal food, although he is occasionally driven by hunger to steal a pig. Sometimes he has been known to attack and kill even a cow. He is a noted depredator on maize and melon fields; honey is his delight. He is a great climber,

FIG. 3.—CINNAMON BEAR (*Ursus occidentalis*).

and an assiduous searcher for "bee-trees," which he no sooner finds than climbs, proceeding to gnaw through the trunk to the nest of the bees. As soon as an aperture large enough to admit his paw has been made, honey, comb, and bees are scraped with avidity into his capacious mouth.

The black bear is common all over the eastern division of the United States, from Maine to Florida, and in fact over a large part of the Western territory. In the colder parts of this area it hibernates, but the habit does not seem to be general, at least with the males in the warmer parts. It is said that even in the cold latitudes it will

not hibernate, unless it is fat at the beginning of the winter. The young, varying from one to four in number, are brought forth during hibernation in January or February. At first they are not more than six to eight inches long, and are covered with gray hair. They retain this color until the second year, when it gives place to black. The yellow Carolina bear is merely the young black bear assuming its distinctive color.

The black bear is much hunted for its skin, and the fat which constitutes the esteemed bear's-grease of commerce. Its numbers have been greatly diminished from this fact. Its flesh forms a good article of food, resembling pork, but with a peculiar flavor. Although easily tamed and naturally docile, it is a dangerous combatant when pursued and roused. The cinnamon bear (*Ursus occidentalis*) is a variety of the black bear, differing in color, as indicated by its name. It is found in California, and generally west of the Rocky Mountains.

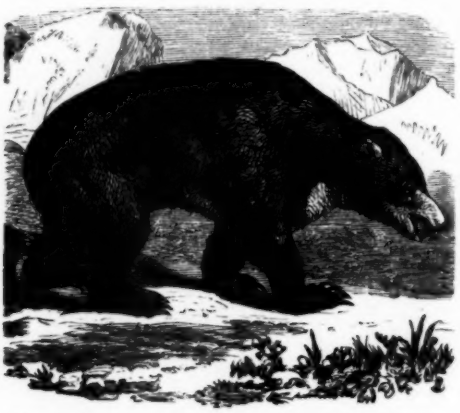


FIG. 4.—MALAYAN SUN-BEAR (*Helarctos Malayanus*).

In the building to the west of the Museum we find a small female specimen of the Malayan sun-bear (*Helarctos Malayanus*). It no sooner observes us pause, than it rears up and extends its paw through the bars in a singularly imploring manner to induce us to give it some food. This, however, we are politely warned against doing by the following notice, "*Please don't feed the animals!*" which is placed against the cage. The Malayan bear is one of the smallest of the *Ursidæ* family, being at its greatest development only about four feet six inches long. Its color is deep black, with a yellowish muzzle and a white spot on the breast in the shape of a crescent with the horns turned up. The neck is shorter and thicker than in other species. Its diet is chiefly vegetable, the cocoa-nut being its favorite food. It is very destructive to the cocoa-nut groves, from its habit of devouring the succulent shoots that crown the tree. It is easily tamed, and becomes

extremely docile and amusing. The name sun-bear (*Helarctos*) has been applied to the animal to indicate its habit of basking in the sun.

The spectacled bear (*Ursus ornatus*), inhabiting the Cordilleras of South America, displays all the distinctive features of the Malayan spe-

FIG. 5.—THE SPECTACLED BEAR (*Ursus ornatus*).

cies except the semicircular white patches over the eyes which give it its name. The two are evidently varieties of the same species.

The brown bear (*Ursus arctos*) is the most widely distributed of all the species. It is found throughout Europe and Northern Asia, from Scandinavia to the Himalayas. In size it is superior to the black bear of America, but inferior to the polar bear. The length is generally from about five feet, and the weight five to six hundred pounds, although it sometimes attains to seven or eight hundred pounds. The color is brown, slightly variable in tint with different individuals, and with the same individual at different ages. The neck of the younger animal is in some cases encircled by a white collar, which disappears as age increases. The prominence of the brow is much more marked than in other species, the soles longer, the claws smaller. It hibernates during the winter in caves and hollow trees, and, where these are not to be found, in holes dug into the earth and covered with moss. From one to four cubs are produced at a time. The principal food of the brown bear is vegetable substances, honey, and the larvæ of the ant. Like the black bear, it is an excellent climber, and wages relentless warfare against the bees. The taste for animal food seems to be not altogether natural, but when once acquired is never lost. An individual having tasted blood will continue to depredate on the neighboring folds until he falls a victim to the indignation of the farmer.

It will occasionally attack man, especially in the colder parts of its range, and is always dangerous and ferocious in combat. The Scandinavians say in regard to this bear that it "has the strength of ten

men and the sense of twelve." They also have a superstitious reverence for it, and habitually avoid saying "the bear" by using such appellations as the "*old man with the fur cloak*," the "*disturber*," the "*dog of God*," etc. The Indians of America have a similar reverence for the black bear. The killing of one is always followed by a religious ceremony designed to conciliate the manes of the dead animal. The head is decorated with trinkets and placed upon a blanket, where the successful hunter blows tobacco-smoke into the nostrils, and

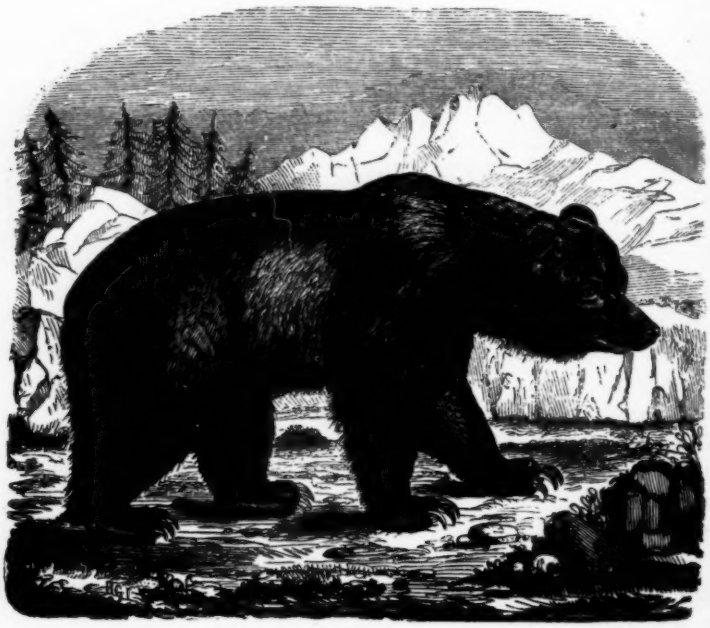


FIG. 6.—THE BROWN BEAR (*Ursus arctos*).

makes a conciliatory speech, regretting the necessity for the killing. As an instance of the cunning of the brown bear, it is related that, when he is desirous of attacking man, the circle of fire, which proves such an effectual safeguard against other animals, is of no avail against him. He will not attempt to walk through the flames, but retiring, immersing himself in the nearest stream, will return and roll his body over the brands until the flames are smothered, when he will attack the sleeper. Yet for all this he is, when in good condition, a gentle and humorous fellow. Two children of a Siberian farmer, aged four and six respectively, one day wandered away from home. The parents, in searching for their children, were amazed to discover them at play with a large bear. One of the children was mounted upon the bear's back, while the other was feeding him with berries. The terrified parents began to scream, whereupon the bear quietly left the children and

went into the wood. The brown bear is spread over Asia, from the Himalayas northward, but in different localities it undergoes slight modifications of color, and has therefore received different names; hence the Siberian bear (*Ursus collaris*), and the Syrian bear (*U. Isabellinus*). The former is said to have a white collar around the neck,

FIG. 7.—SYRIAN BEAR (*Ursus Isabellinus*).

which is probably the distinctive mark of the younger bear. In the latter, the brown color changes into a yellowish hue, from which the term Isabel bear is derived. The brown bear of the Himalayas is of the same species. It seems likely also that it inhabits the extreme northwestern part of North America. Sir John Richardson relates having found in the barren lands lying to the northward and eastward of the Great Slave Lake, extending to the Arctic Sea, a bear which agrees with this in many respects. Still, nothing definite is known to establish the identity of the two.

One of the most curious members of the bear family is the Asiatic or sloth bear (*Ursus labiatus*). It is distinguished from other bears by the length of its hair, the length and flexibility of its lips, and the peculiar manner in which the fore-feet cross each other in walking. Its fur is deep-black, slightly flecked with brown, but it has a forked patch of white upon the breast. The hair from the head and neck hangs down over the face, and gives the animal a weird appearance. It seems to be subject to the early loss of its incisor teeth, from the absence of which, in the first specimens carried to England, it was supposed to be a species of gigantic sloth. It is almost wholly a vegetable feeder, and, it is said, will resort to animal food only in cases of extreme hunger. It is quite harmless unless retreat is cut off, when, like its relatives, it becomes savage and dangerous. The mother will fight bravely in defense of her young, which she usually carries upon her back until they have acquired strength enough to make good travelers. It is an inhabitant of the Himalayas, where it remains in caves

during the day, and performs its rambles by night. This habit is attributed to the fact that the soles of its feet are covered by a skin so tender as to be easily blistered by the sun-heated rocks which constitute the surface of its mountain-home.

In the polar bear (*Ursus maritimus*) the bear family possesses an aquatic member. It is inferior in size only to the grizzly bear, and is scarcely second to him in strength and ferocity. Its color is silvery white, tinged with a slightly yellowish hue, which varies in intensity with different individuals. The neck is longer in proportion to the

FIG. 8.—ASIATIC OR SLOTH BEAR (*Ursus labiatus*).

body than in any other bear, and the head is far smaller, and very much pointed. It is also characterized by almost entire absence of facial angle, there being a nearly unbroken line of descent from the forehead to the nose. The foot, also, is of greater comparative length, being about one-sixth the length of the body, while in the brown bear it is only one-tenth. The sole is covered with a thick fur, which enables the animal to tread firmly upon the ice. The claws are slightly curved, though not very long. They are quite black, so that they stand out in strong contrast with the fur surrounding them.

The polar bear is necessarily carnivorous, from the circumstances under which it exists, vegetable food being absent from its icy haunts; however, when captured and brought to warmer latitudes, it will subsist on a vegetable diet. It lives on fish and seals, and is said to occasionally capture a walrus. Its movements are remarkably quick. One was observed to dive from a block of ice and capture a passing salmon. Its mode of capturing the seal evidences much sagacity. Observing the position of the basking seal, it dives into the water and swims in that direction beneath the surface, occasionally sticking out its nose to "catch a breath." Proceeding thus, it rises at length close to the seal, which, cut off from the water, falls an easy prey, escape over the ice being impossible, on account of the swifter movements of the bear.

This bear seldom attacks man if unmolested. The pregnant females hibernate, but the males and other females do not. The first scrapes a hole into the snow, where, buried as it were, she passes the winter, bringing forth her babies, generally two in number, during that time. The mother will always die before leaving her cubs in danger, and, if they be killed first, she is said to make a most affecting display of grief. The flesh of the polar bear is highly esteemed by the arctic voyagers as an article of food.

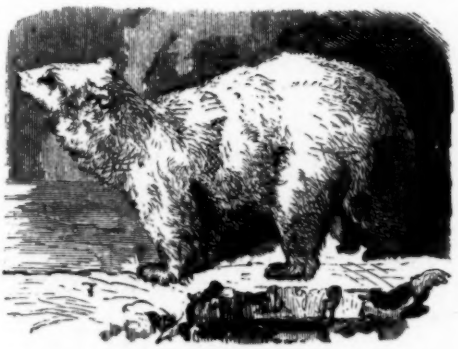


FIG. 9.—POLAR OR WHITE BEAR (*Ursus maritimus*)

Scattered throughout Europe are the remains of extinct bears, usually found in caves, from which fact they are said to belong to the cave-bear. They have been divided into two species, *Ursus spelæus* and *Ursus priscus*. The former is larger than any living species. In a recent number of the *Popular Science Review*, Mr. A. Leith Adams, M. B., F. R. S., makes an interesting attempt to establish the identity of the grizzly and the *Ursus spelæus*. He thinks that the former was at one time common to Europe, and that the latter were only larger individuals of the same species. He was led to this conclusion from observations on the brown bear of the Himalayas, in which species he found that certain males occasionally grow much larger than the average, and that such are peculiarly addicted to living in caves, from which they seldom wander except for a few hours daily. It seems, also, that certain slight modifications of the skeleton occur in the overgrown individuals. Reasoning from analogy, he concludes that, when means of subsistence were abundant in Europe, it is likely that a similar peculiarity of excessive growth in certain individuals also characterized the grizzly species. This hypothesis, he thinks, sufficiently accounts for the difference in size, while the cave-loving habits of the larger individuals would explain the preservation of their remains. The *Ursus priscus* he regards as identical with the brown bear (*Ursus arctos*).

Regarding the distribution of bears, we have found the grizzly re-

stricted to the Rocky Mountains and the adjacent plains; while the black bear takes his place in other parts of the North American Continent, except in the extreme northwest. The Malayan bear we found distributed over the archipelago that bears its name, the southern part of Asia, and even South America, though with slight modifications. The brown bear (*Ursus arctos*), we have seen, holds undisputed sway of Europe, of Asia north of the Himalayas, and that it probably extends even to the northwestern part of North America. And, in marked contrast with this wide range, we find the sloth-bear confined to the Himalayas, and the polar bear to the Arctic Ocean.

WOMAN'S PLACE IN NATURE.

By FRANCES EMILY WHITE, M. D.

PROGRESS in knowledge is defined by Herbert Spencer as "the bringing of thoughts into harmony with things." Plato enunciated the same great truth more than two thousand years ago. "Man," he says, "is not a system-builder; his loftiest attainment reaches no higher than this: through endeavor, through discipline, through virtue, he may *see* what *is*." Recognizing the profound wisdom of these utterances of the ancient and the modern master, I propose, in studying the nature and place of woman, to be guided by this principle, which has led to results so satisfactory in other departments of science, and, forgetting theories, to study woman as she is. Should some onward glances be attempted, "a scientific use of the imagination" only will be indulged in, and the possibilities of the future will be inferred from the actualities of the past and the present.

As man's place in Nature is to be comprehended only by comparison with the various grades of organisms below him in the scale of being, so woman's place, as compared with that of man, is to be rightly understood only by a study of the relations of the sexes through the whole range of organized beings, involving a consideration of vegetable existence even, since sex accompanies all its higher forms. Paradoxical as it may seem, the less includes the greater—evolution being an unrolling or unfolding of that which potentially exists. It is by means of such a review, if at all, that we may hope to find answer to the questions of the day, relating to woman. How does she differ from man, and to what extent do these differences modify or determine her place in life? In other words, how does that differentiation of the human germ which we designate as feminine, influence the organism as a whole? Will these questions admit of complete solution? Probably not; no great question has ever yet been fully answered—and, although the human organism may be divided, for purposes of

study, into numerous sets of apparatus, each having a definite office in the general economy—as the digestive apparatus, the reproductive, the intellectual, etc.—the correlation of all the forces and functions of the body is so intimate and subtile that true philosophy makes no attempt to measure the exact and separate influence of any one force or function upon the rest, or upon the organism as a whole. Hence, to estimate the influence of sex in any given organism is impossible upon general principles, and evidently so in the case under consideration, from the fact that there is no standard of comparison. To assume man as the staudard would be obviously absurd, for he is as distinctively differentiated as is woman, and it is impossible for a scientific imagination to conceive of a common type of the human species excluding the idea of sex; the attempt would demonstrate the impossibility of separating the mental conception of its two phases—just as it would be impossible to conceive of a magnetic needle without polarity. Its opposite poles may be designated and described, their peculiarities discussed, and their superficial relations partially understood; but who has any distinct idea of the real significance of their relations? The only clear thought is that they are complemental, and incapable of separate existence—furnishing a complete example of perfect duality in perfect unity; and the absurdity of the idea of a "common type" of its two poles is obvious. If any thing, it would be a magnetic needle without magnetism; in other words, a conceived inconceivability! Recognizing the difficulties which beset this investigation, then, the most that can be hoped for is the attainment of some broader and deeper truth than appears on the surface of the present disturbances in the social world; the only legitimate inquiry seems to be in regard to the influences and conditions which have resulted in the woman of to-day; and the practical questions related to it: Is there a tendency toward any important change in these influences and conditions, and, if so, in what direction? From what has gone before, my readers will have already inferred that the study of this subject will unavoidably include that of its natural complement, and that, should we succeed in obtaining answer to these questions, others of equal interest will find solution.

While the distinction of sex has for its manifest object the continuation of the race, that it is of deeper significance than this—that it has important bearings upon race-development as well as race-preservation—is indicated by a mass of evidence of so great weight as to carry with it the force of a demonstration. In Darwin's "Descent of Man" we have an accumulation of statements of facts gathered from vast fields of observation by many of the foremost naturalists of the age; and his deductive interpretations of these facts seem to have been accepted by a majority of the leading naturalists and physicists of the day. Such being the case, we are warranted in making this work the basis of our inquiry, thus looking at the subject from the

side of natural history. Should some additional deductions and interpretations be brought out, it is hoped that they will not be found either forced or imaginary.

In order to a clear understanding of the line of reasoning employed, we must distinguish between the terms "natural selection" and "sexual selection," as used by Darwin. The traits resulting from these two processes are under a different law of heredity—those arising through natural selection being transmitted alike to the young of both sexes, while the results of sexual selection are inherited mainly by the adults of the corresponding sex. It will be seen that these are important laws, and that they furnish a key to our inquiry into the conditions and influences which have resulted in the woman of to-day. Under the operation of this second law (quoting from the "Descent of Man"), "it is the male which, with rare exceptions, has been chiefly modified—the female remaining more like the young of her own species, and more like the other members of the same group. The cause of this seems to lie in the males of almost all animals having stronger passions than the females. Hence it is that the males fight together, and sedulously display their charms before the females; and those which are victorious transmit their superiority to their male offspring." The question naturally arises, How have the males of the lower animals acquired this greater strength of passion? Says Darwin: "It would be no advantage, and some loss of power, if both sexes were mutually to search for each other; but why should the male almost always be the seeker?" Reasoning from the lower forms of life, he points out the fact that the ovules, developed in the female organs of plants, must be nourished for a time after fertilization; hence the pollen is necessarily brought to them—being conveyed to the stigma by insects, by winds, or by the spontaneous movements of the stamens themselves, upon which the pollen grows. "With lowly-organized animals permanently affixed to the same spot, and having their sexes separate, the male element is invariably brought to the female; and we can see the reason; for the ova, even if detached before being fertilized, and not requiring subsequent nourishment or protection, would be, from their larger relative size, less easily transported than the male element. . . . In case of animals having little power of locomotion, the fertilizing element must be trusted to the risk of at least a short transit through the waters of the sea. It, would, therefore be a great advantage to such animals, as their organization became perfected, if the males, when ready to emit the fertilizing element, were to acquire the habit of approaching the female. The males of various lowly-organized animals having thus aboriginally acquired the habit of seeking the females, the same habit would naturally be transmitted to their more highly-developed male descendants; and, in order that they should become efficient seekers, they would have to be endowed with strong passions. The acquirement of such passions would naturally

follow from the more eager males leaving a larger number of offspring than the less eager."

I have quoted thus at length upon this point, in accordance with the principle already laid down, that the lower is a type of the higher.

Following Darwin's argument—"the greater eagerness of the male has thus indirectly led to the more frequent development of secondary sexual characters in the male than in the female"—secondary sexual characters being those not directly concerned in reproduction. Among these are the greater size, strength, courage, and pugnacity of the male, which most naturalists admit to have been acquired or modified by sexual selection—not depending on any superiority in the general struggle for life, but on certain individuals of one sex, generally the male, having been successful in conquering other males, and thus having left a larger number of offspring to inherit their superiority.

In the human species, the differences between the sexes are marked. The greater size and strength of man are apparent. His broader shoulders, more powerful muscles, greater physical courage and pugnacity, may be plainly claimed, by Darwin and his adherents, as man's inheritance from a long line of ancestry, of which the vanishing-point is in the remote past, among the lowest forms of life.

Whether or not this relationship be accepted, the same principles which have prevailed among lower animals must have been operative in the progress and development of the human race.

During the long ages when man was in a condition of barbarism, it must have been the strongest and boldest hunters and warriors who would succeed best in the struggle for existence, thus improving the race through the operation of natural selection, and the survival of the fittest; while the stronger passions accompanying these traits would lead to their success in securing the wives of their choice.

They would necessarily, by means of the same advantages, leave a more numerous progeny than their less successful rivals. It is here that the laws of sexual selection and heredity come in to maintain and increase the differences between the sexes. Who can doubt that a difference in mental characteristics would result from such causes? The greater necessity for exertion on the part of men would inevitably result in the development of more robust intellects. "Mere bodily size and strength would do little for victory unless associated with courage, perseverance, and determined energy.

"To avoid enemies or to attack them successfully, to capture wild animals, and to invent and fashion weapons, require the aid of the higher mental faculties, namely: observation, reason, invention, or imagination. These various faculties will thus have been continually put to the test and selected during manhood; they will, moreover, have been strengthened by use during this same period of life.

"Consequently, in accordance with the principle often alluded to, we might expect that they would at least tend to be transmitted chiefly

to the male offspring at the corresponding period of manhood. . . . These faculties will have been developed in man partly through sexual selection, that is, through the contests of rival males, and partly through natural selection, that is, from success in the general struggle for life. . . .

"Thus," continues Darwin, "man has ultimately become superior to woman." We will say, rather, thus have men and women come to differ mentally as well as physically. We will take further testimony, and inquire what sexual selection has been accomplishing for women during these long periods of man's physical and mental development, before accepting the unmodified dictum of superiority.

The authority so frequently quoted tells us that "the equal transmission of characters to both sexes is the commonest form of inheritance," and that "this form has commonly prevailed throughout the whole class of mammals." Hence the advantages primarily gained by man have been bestowed upon his descendants of both sexes, though, as has been shown, in a somewhat less degree upon the female. Let us now glance at the converse of these vivid pictures of the advantages accruing to man through habits and conditions arising from primary sexual characters, and endeavor to learn whether the habits and conditions necessarily attaching to the female have been the source of any gain either to herself or to the race as a whole.

The less degree of hardship and exposure to which she has been subjected have doubtless tended to develop in her the physical beauty in which she is generally acknowledged to be man's superior; while the fact that women have long been selected and prized for their beauty will have tended, on the principle of sexual selection, to increase the differences originally acquired through natural selection.

The "sweet low voice" which has so long been accounted "an excellent thing in woman," has undoubtedly been gained in a similar manner. In the pursuit of her more quiet avocations there would be less likelihood of the development of large and powerful vocal organs, as it is during the excitements of battle and the chase that the fiercest yells and wildest shouts are produced. The perception of musical cadences, and a sensitiveness to the influence of rhythm, manifested even by many of the lower animals, naturally associating themselves with the rhythm of motion, would tend to early development, on the part of the female, in the care and nursing of her young; while sexual selection has probably played a still more important part in the origin of music.

"Although," says Darwin, "the sounds emitted by animals of all kinds serve many purposes, a strong case can be made out that the vocal organs were primarily used and perfected in relation to the propagation of the species."

Many of the lower animals are mute except during the breeding-season, and the calls, melodious or frightful, of most animals have

either a social, an amatory, or a maternal meaning. Thus, through the principle of inherited associations, music asserts its sway over the deepest emotions of the nature — spoken of by Herbert Spencer as arousing "dormant sentiments of which we had not conceived the possibility, and do not know the meaning," and apostrophized as follows by the more impassioned Richter: "Away! thou tellest me of that which I have not and never can have; which I forever seek, and never find!" Its mysterious influence is explained by Darwin as consisting in its power of exciting sensations and ideas which "appear from their vagueness, yet depth, like mental reversions to the emotions and thoughts of a long-past age."

Woman, unable to obtain an influence by those means so readily at the command of man, will have naturally resorted to milder measures, both for securing any desired object, and in self-defense; and music, appealing as it does to the gentler and more tender emotions, will have been often employed in arousing the better nature of him at whose mercy her inferior strength has placed her. Thus she will have held the ruder passions of man in check, and, in taming his wilder nature, will have developed an increasing gentleness both of feelings and of manners in the entire race.

During the battles of rival males, the female will have occupied the less active but more dignified position of arbiter and judge. Not being in the heat of the conflict, she will have had opportunity to observe the strategy of each, and to weigh their comparative merits. By this exercise of the faculties of observation, comparison, judgment, and reason, her intellectual powers will have been "continually put to the test and selected during" womanhood. Unfairness in the conduct of the battle will doubtless have roused her indignation, and compelled her better feelings in favor of the more honorable combatant. Sympathy for the vanquished will sometimes have taken the place of exultation in the superior prowess of the victor, and admiration for mere muscular power will have had to contend with these finer emotions.

While man has been engaged in contests with the common enemy, during which his fiercest passions will have been aroused, woman has been subjected to the discipline of family life. To meet emergencies successfully, to provide for the sick, to maintain order and discipline in the household, which, at an early period in human history, included slaves as well as children, will have required mental powers of a high order. At the same time she will have developed a milder character through the exercise of the beneficent traits of maternal love, and solicitude for the absent husband and father. These feelings of tenderness and love will have gradually prepared the way for the development of the devotional sentiment, and will have thus furnished a basis for the deeper religious nature which has become a part of woman's birthright.

Darwin says that the foundation of the moral qualities lies in the

social instincts, including in this term the family ties—the more important elements being love and sympathy.

Thus it appears that while sexual selection and intellectual development have gone hand-in-hand, it is no less true that the moral and emotional sides of human nature have been developed by the operation of the same laws mainly through the female portion of the race. Though Darwin scarcely does more than touch upon this phase of the subject, he says: "Woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness;" and again: "It is indeed fortunate that the law of equal transmission of characters to both sexes has commonly prevailed throughout the whole class of mammals; otherwise it is probable that man would have become as superior in mental endowments to woman as the peacock is in ornamental plumage to the peahen."

I shall refrain from indulging in any "would-have-beens" upon the moral aspects of this picture, in the contingency to which Darwin alludes, since we are concerned only with what *is*.

Our authority continues; "That there is a tendency to the equalizing of the sexes is undoubted in many of the secondary sexual characteristics; woman bestows these superior qualities on her offspring of both sexes."

Applying the principles, to the operation of which he imputes man's mental superiority, we will add—though in a greater degree upon her adult female offspring, since it is during her maturity that these qualities of greater tenderness and less selfishness are most called into exercise.

Although Darwin states that man has been more modified than woman by the law of heredity in connection with sexual selection, he admits its force in the development of both sexes by many statements which might be quoted, were it necessary. The principal argument against its equal force in the two cases is found in the fact that the young of both sexes in many animals, including the human, most resemble the mother. While this is true in a limited sense, the points of greater resemblance being mainly of a physical character, as superior softness and smoothness of skin, greater delicacy of muscles, muscular tissue, etc., it is not applicable to the qualities of tenderness and unselfishness, the cruelty and selfishness of children, especially boys, being proverbial.

Still quoting from the same work: "Although men do not now fight for the sake of obtaining wives, and this form of selection has passed away, yet they generally have to undergo, during manhood, a severe struggle in order to maintain themselves and their families, and this will tend to keep up, or even increase, their mental powers, and, as a consequence, the present inequality between the sexes. . . . In order that woman should reach the same standard as man, she ought, when nearly adult, to be trained to energy and perseverance, and to

have her reason and imagination exercised to the highest point; and then she would probably transmit these qualities chiefly to her adult daughters. The whole body of women, however, could not be thus raised, unless, during many generations, the women who excelled in the above robust virtues were married, and produced offspring in larger numbers than other women."

Though the writer appears to see no incompatibility in these two conditions of the intellectual elevation of women, doubtless many of my readers will, particularly such of them as have borne and raised large families.

Herbert Spencer says: "Taking degree of nervous organization as the chief correlative of mental capacity, and remembering the physiological cost of that discipline whereby high mental capacity is reached, we may suspect that nervous organization is very expensive; the inference being that bringing it up to the level it reaches in man, whose digestive system, by no means large, has at the same time to supply materials for general growth and daily waste, involves a great retardation of maturity and sexual genesis." This is a general statement, applicable to the race as a whole, but it follows that, in so far as reproduction is a greater physical tax upon woman than upon man, so far she labors under a natural disability to equal man intellectually, there being a necessary antagonism between self-evolution and race-evolution, since energy expanded in one direction is not available in another.

Darwin, in suggesting a method—evidently impracticable, however—by which women may become the intellectual peers of men, fails to provide for the elevation of man to a moral equality with woman, although he admits that "the moral faculties are generally esteemed, and with justice, as of higher value than the intellectual powers." He says also that "the moral nature of man has reached the highest standard as yet attained, partly through the advancement of the reasoning powers and consequently of a just public opinion, but especially through the sympathies being rendered more tender and widely diffused."

In regard to the future progress of the race, Herbert Spencer asks "in what particular ways this further evolution, this higher life, this greater coördination of actions may be expected to show itself;" and concludes[1] that it will not be in the direction of increased muscular strength, but somewhat in an increase of mechanical skill, largely in intelligence, but most largely in morality.

Thus these high authorities assign to woman a place in the production of those influences which have developed and must continue to develop mankind, coextensive in importance with the moral interests of the race.

But, if I have read their teachings aright, neither man nor woman

[1] For argument, see "Principles of Biology," vol. ii., p. 495.

can justly take any individual pride, the one in his intellectual, the other in her moral superiority; rather they must see themselves as

"Parts and proportions of a wondrous whole;"

as the accompanying movements which make up the harmony of the grand diapason of the human race.

And there is that just adaptation of the different parts which is essential to and constitutes harmony. Bacon says that the causes of harmony are equality and correspondence; and Pope completes our argument with the line—

"All discord, harmony not understood."

There can be, then, no real conflict of interests between man and woman, since there is a mutual dependence of each upon the other, bringing mutual good. Neither can it be a misfortune to be a woman, as so many at the present day would have us believe, although her position may be in some respects subordinate to that of man.

In fact, the subordination of man to woman, different in kind from its converse, is equally apparent; both seem to be matters of common consciousness. It may be readily seen how, in early times, when muscular strength and general physical power were held in the highest esteem, that the position of woman should have been a subordinate one. Animal courage, endurance of physical hardships, the strength, cunning, and agility, which enabled men to cope with wild beasts and with each other, were the traits of character most prized, because most conservative of life in those barbarous times; hence the idea that, woman's position is naturally a subordinate one, has acquired the force of a primal intuition, and might almost be claimed as a "datum of consciousness." But, as the necessities of existence have been gradually modified by civilization, both the character and degree of her subordination have notably changed.

Those qualities, regarded as preëminently feminine, have risen in common estimation, and mere muscular superiority, and even intellectual power, are now put to the test of comparison with the higher moral qualities.

It is true that the laws of most countries still discriminate in a manner unfavorable to women. Legislation has been largely upon the ideal basis of every woman being under the protection of some man, and of all men being the true defenders of all women, and this is evidently traceable to the conviction, already alluded to, that a subordidate position belongs naturally to woman. Lecky says that "the change from the ideal of paganism to the ideal of Christianity was a change from a type which was essentially male to a type which was essentially feminine." As the race shall continue to approach the level of its lofty ideal, the subordination of woman, as well as that of man, will continue to lessen, since both have their chief foundation in

the lower traits of character, the force in the one case being superior strength combined with power of will, and, in the other, superior beauty with the desire to fascinate. As these influences are gradually losing their power of despotic sway, woman, in place of acting as the slave, the toy, or the tyrant of man, is becoming not only his companion, but the custodian of the moral and religious interests of society, man looking at her as the natural critic and judge of the moral aspects of his conduct.

While the varying characteristics of the two sexes are thus seen to be inherent and inevitable (the secondary sexual characters having largely grown out of those which are primary and essential), it does not follow that they are necessarily indicative of the "sphere" of each for all time. While it is doubtless true, in a certain sense, that "that which has been is that which shall be," nevertheless, change (in accordance with law) underlies the very idea of evolution, and as it has been and is now, so it ever shall be, that the sphere of woman will be determined by the kind and degree of development to which she shall attain. Like man, she need know no other limitation; but when we look around upon the great industries of life, mining, engineering, manufacturing, commerce, and the rest, and consider how little direct agency woman has had in bringing them to their present stage of progress, we are compelled to believe that she must not look toward direct competition with man for the best unfolding of her powers, but rather, while continuing to supplement him, as he does her, in the varied interests of their common life, that her future progress, as in the past, will consist mainly in the development of a higher character of womanhood through the selection and consequent intension of those traits peculiar to her own sex.

THE HERMIT OF RED-COAT'S GREEN.

By DANIEL H. TUKE, M.D., M.R.C.P.

EVERYBODY remembers Mopes, the "slothful, unsavory, nasty reversal of the laws of human nature"—Dickens's famous character of "Tom Tiddler's Ground." The recent death of the original of that sketch has attracted fresh notice to his strange mode of life. I propose to consider the question of his insanity; and whether, if insane, the mental disorder in this and similar cases calls for interference with the individual's liberty.

Mr. James Lucas, the fourth child of an opulent London merchant, was born in 1813; there were five children in all, of whom a brother and sister survive. He had an aunt who, like himself, exhibited a contempt for the ordinary decencies of civilized life, and an uncle who

was also eccentric, though not in an asylum. Nothing is known of the previous generation, except that the paternal grandfather was successful in making money. Lucas was considered a healthy boy in mind and body up to ten years, when he suffered from a ringworm, and had his head shaved, and an ointment, said by a relative to have been very strong, rubbed in. His mother claimed that at this time his character underwent a change. She said that "he was never quite the same" afterward. Whether or not the implied cause[1] be deemed adequate, it is certain that an alteration in his moral character, marked chiefly by waywardness of temper and untruthfulness, occurred at this time. He was spoiled by both parents. It is a striking fact that very many of the patients admitted into York Retreat were unduly indulged when children.

At seven, he was sent to school. He ran away, but was sent back and kept there until he was fourteen. With a view to moral restraint and discipline, he was next sent to Mr. Hicks, a physician of Whitwell. His stay was short: one day during Mr. Hicks's absence, he escaped and took refuge with a relative, who refused to give him up. Mr. Hicks, who is still living, remembers the lad, and tells me that he regarded him as the victim of ill-judged indulgence and injudicious treatment. He displayed "incorrigible perverseness and obstinacy, combined with a certain amount of cunning." Mr. Hicks learned nothing of his previous condition except that, when driven out for an airing, he would, if taken from the carriage, stand still and shut his eyes.

He returned home, but his father was totally unable to manage him. He was self-willed, obstinate, impatient of restraint. Thwarted in any of his wishes, he took offense, and shut himself in his bedroom for days together, spending therein, it seems, the greater part of his time. He would not refuse to eat his meals if they were left at his door, but he resolutely refused to return the plates, until, at length, his room contained nearly all the crockery in the house. At one time he would put on but little clothing; at another, dress like a fop. On account of these eccentricities, his father moved into the country, but shortly returned, as he there fell into low company and became less controllable. He next would not allow the cinders to be removed from his grate, thus keeping the family in constant dread that he would set the house on fire. He objected so much to an attendant, that one who had been procured was discharged.

At his seventeenth year his father died. At twenty, his conduct became unbearable, and by medical advice he was forced to have a constant attendant. This supervision, which lasted two years, showed how his state of mind was regarded by those competent to judge—

[1] Mr. Erasmus Wilson states that no case ever came to his knowledge of a mental affection resulting from local applications to the scalp. I find from Dr. Russell Reynolds, that he has had patients suffering from disorder of the emotions consequent on the use of hair-dyes.

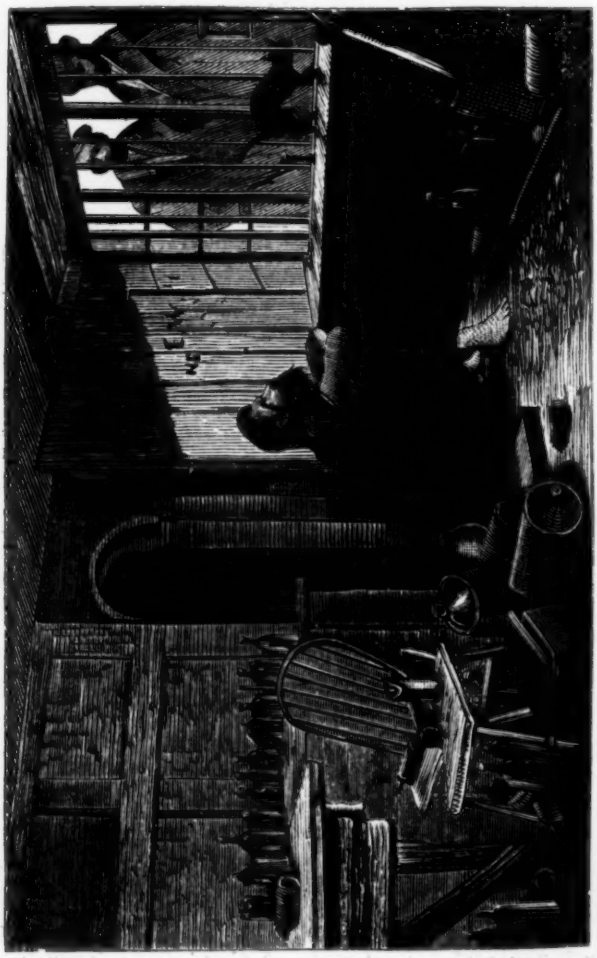
the late Dr. Sutherland was one of the authorities consulted. It ceased only because his mother intensely disliked it. The family now lived at Red-Coat's Green, near Hitchen, in the house where the hermit afterward lived and died. He hunted occasionally with a gentleman of the neighborhood. He rode either with his shirt outside, or in a nankeen suit, barefooted, with a small cap, or bareheaded, his long hair streaming in the wind. He bestrode a high-peaked saddle, and used a rope for his bridle and stirrups. Sometimes, he would ride in a carriage, his hair done up in curl-papers. He became attentive to a young lady, to whom he sent a pair of doves in a cage, but she returned the present. He persecuted her sadly, by prowling around the house. His mother died in 1849. He was then the eldest surviving son, but a younger one was left executor. A fatal objection to his acting in that capacity was, that he would not sign his name to any paper bearing her Majesty's stamp. He held that she was not the rightful heir to the throne, and would not use a postage or receipt stamp lest he should seem to admit her supremacy. But he did not scruple to use a coin bearing her image.

He kept his mother's body in the house from the 24th of October, 1849, to January, 1850, promising each day to let her be buried "tomorrow." The greater part of his time was spent beside the corpse. At length his brother interfered and buried the body. It has been published that he was heart-broken at his mother's death. His relatives doubt the depth of this attachment. He, indeed, expressed himself as much attached to her, and intimated that he would die with her; but she often said that he never showed his affection by gratifying one of her wishes. However, he may have felt real sorrow at her death, and this seems to be implied by the fact that he allowed things in the house to remain just as they were when she died; her letters and money untouched, and the beds as they were then made. In fact, his distress seemed genuine. He often told a neighbor that he would willingly have died for her, and he would weep bitterly at the mention of her name.

His life as a hermit now began, but, however great his distress, we cannot attribute to it his strange mode of life. His brother believes that he afterward appeared worse only because all restraint was removed. His brother and sisters could not now live with him. I believe he never saw the latter again, while he became estranged from the former because of his interference about the interment. Lucas spoke in the bitterest terms of his brother, and even left a hay-stack untouched, all his life alleging that he would hold him responsible for it. Still, his brother visited him several times, and was received. It is important to observe that he made a will a few years after his mother's death, wherein he evinced no animosity toward his brother, nor displayed any eccentricity in the disposition of his property. The appearance of the house bespoke the character of the occupant. Win-

dows and doors were carefully barricaded, and the house was allowed to go to ruin; so likewise was the garden. A tree which fell across the walk was not cleared away except to allow a passage to the house.

I visited the hermit some years ago, going up to the window of what had been the kitchen. Glass and casement had long disappeared;



PORTRAIT OF THE HERMIT.

the strong upright iron bars alone remained. Here the possessor of ample means, a man of at least fair education, lived day and night. He appeared to emerge from a bed of ashes.[1] He had not slept in a bed for many years. He came forward, and entered, rather reluc-

[1] I observed that, when his room was entered after death, the floor was found to be covered two or more feet with cinders that had accumulated. A farmer informs me that he has since removed fourteen cart-loads of cinders from the house and around it.

tantly, into conversation, with a suspicious expression. Unwashed for many years, his skin was in an undesirable condition, the whites of his eyes contrasting strangely with the rest of his face. Clothes he had none; only a dirty blanket loosely thrown over him. His hair, long a stranger to scissors or razor, was matted with dirt. He was about five feet six inches high, rather muscular, with dark hair and eyes, the latter prominent, and pale complexion. His forehead appeared well developed. The room had a fire, an old table, a chair, and numerous bottles. It is said he suspended a basket from the ceiling to keep his food from the rats. He spoke to me in a low, rather plaintive tone, which impressed me that he was laboring under a certain amount of fear or apprehension. Part of his conversation, otherwise perfectly rational, conveyed the same impression. He intimated that his relations were against him, and I understood him to assign it as the reason why his house was barricaded. He appeared to be laboring under a partial insanity—a monomania of suspicion or persecution. Whatever reasons he may have subsequently had for barricading his house, his brother informs me that some panes of glass were actually broken by stones during the papal aggression in 1850, because he leaned to Romanism, and then it was that bars of wood were nailed across the windows.

He wrote no letters, nor wrote at all, that I know of, except upon a check. He had a check-book and used it to pay some of his bills. When he required money, his bankers received a verbal message, and sent a clerk to transact business with him. The check was always very correctly written, and the counterfoil duly filled in. On his last check, dated April 14, 1874, the signature, unlike the previous ones, was rather shaky. Because of his antipathy to stamps, the receipt-stamp had to be added afterward. The dividend-warrants that came to him remained uncashed for the same reason, forming a large collection of very dirty papers. About four years ago he was induced to authorize his bankers to receive his dividends, and thus surmounted his scruple to recognize the queen. Landed property of his at Liverpool, required for public purposes, was sold under compulsion because he would not become a party to the sale, as it involved the use of a stamp. The money was placed in the Bank of England, and remained there to his death, because he would not use a stamp to draw it out. I have a curious proof of his shrewdness and desire to get the money. A solicitor he knew had some connection with the Court of Chancery. One day he suggested to him to file a bill in chancery to obtain the money. His visitor replied that the court would then institute an inquiry into the condition of the owner. "What!" asked Lucas, alarmed, "do you mean *de lunatico?*" An affirmative answer killed the scheme.

Lucas was not a miser. He gave to swarms of tramps, in coppers and gin, giving always more to a Romanist than a Protestant. It is

said that on last Good Friday he doled out sweetmeats, coppers, gin-and-water (large quantities of which he always kept on hand) to two hundred children. For some years he gave a poor old woman four shillings a week. His diet was simple, though not scant. He ate bread, cheese, and red herrings, and drank both milk and gin. Once, however, he gave up milk—and this, of course, is an important feature of his case—because he suspected that poison had been put into it. At one time he charged a farmer who supplied him with eggs with putting poison into them. When the farmer replied that it would be rather a difficult thing to do, he said that some poison must have been given to the *old hen*. He did not habitually drink to excess, but was occasionally drunk. It is supposed that he drank largely of gin the evening before his death, while feeling depressed. Fear of poison frequently led him to change his baker, and he carefully selected a loaf. In his room was found nearly a cart-load of loaves which he probably suspected of containing poison.

He died of apoplexy at sixty-one, on the 19th of April last. A week before his death he appeared as well as usual; he was, in fact, lively and communicative, and seemingly without any unfriendly spirit or delusion regarding his friends. He spoke with an asthmatic visitor very intelligently of the symptoms and causes of that disease. He remembered the number of years (seven) since he had seen him, and the subject discussed, which the visitor had forgotten. Sometimes, however, he complained of losing his memory, and it was noticed latterly that in using a Greek word—he partially remembered both Greek and Latin—he could not recall the whole of it, and, contrary to his custom, would be at a loss for a word. One who frequently visited him says that he was sometimes low-spirited, crying like a child, bemoaning his condition, and attributing it to the unkindness of his brother, which I know to be entirely false. At other times, if contradicted, he would fly into a passion, swear, and act so violently that his guest would be glad to get out of the house. Because, while this visitor was present once, a medical man happened to call, he quarreled with him, and suspected the two of a conspiracy.

That there was no imbecility of mind may at once be granted. His conversation was coherent and sensible; he was shrewd and wide awake in the ordinary transactions of his limited life, and he fully understood the value of money; his memory was remarkably retentive.[1] Most of his visitors failed to detect any signs of madness, and it is doubtful whether any jury would have found him insane. The commissioners considered his case in 1853, and took the testimony of his brother and a neighbor, but concluded that there was not sufficient

[1] One of his visitors, a traveled man, was surprised to find that Lucas had so much acquaintance with the various localities which turned up in conversation. His knowledge of Shakespeare and of the literature of the Restoration was very considerable. A medical man informs me that, in conversing with him about the classics, he displayed much intelligence.

evidence to warrant an interference. Mr. Forster saw the hermit last year, and found him singularly acute, without the least trace of mental aberration. He said to that gentleman: "You may think it strange my living like this. So do I sometimes, but it is not done without a reason." Nor could Forster's friend, Dickens, recognize the signs of madness in his behavior.

On the other hand, there is the family history pointing to hereditary predisposition to insanity, only wanting some exciting cause to develop it; also the change of character at ten, with an alleged physical cause; the action, as a moral cause, of an injuriously indulgent rearing; the constant waywardness, obstinate willfulness, in a word, wrongheadedness; the acts which frequently alarmed his family; the necessity at length of legal restraint; the freaks regarding dress; his extraordinary conduct on the death of his mother; the persistent delusion respecting the queen, involving much loss of property; the entire neglect of his dwelling and person; his groundless suspicion of and antipathy toward his brother; the delusion that poison was put into his food; his fits of mental depression; and his violent passion on the slightest contradiction. These characteristics—in many respects so familiar to us in asylum-life, and so easily conceivable in others if certain cases of insanity we have known had been allowed to develop—prove that the hermit's condition passed the limits of eccentricity, that his emotions were perverted by disease. But, while his case was primarily one of moral insanity—a madness of action rather than language, a state of degraded feeling rather than of intellectual incapacity—his suspicions at times took the form of a definite delusion. It should be carefully borne in mind that his isolated life, and neglect of his residence and dress, did not arise from the preoccupation of his thoughts by any absorbing pursuit. He had none. It arose from his diseased mental condition, and the solution of the problem of his life can be obtained only *by tracing back his history to the unfavorable circumstances of his childhood, acting upon a brain in all probability predisposed to disease.*

Should such a man be interfered with? Interference could not be made on account of the neglect of his property, or of his mode of life. But, conceding his insanity, would it have been desirable to place him under care? He was harmless to others, and also to himself, except in a very general sense; but might he not have been benefited and really more comfortable under medical treatment and control? And answering, as I think this case did, the definition of the law, that there must be "demonstrative proof of the incapacity of the individual to be trusted with himself and his own concerns," it certainly would have saved a great deal of trouble, had he been under the protection of the lord chancellor. I submit that such control would have been better for the neighborhood, for his family, and for the hermit himself.

ADDRESS BEFORE THE AMERICAN ASSOCIATION.[1]

By Prof. JOSEPH LOVERING.

II.

Mathematical Investigations in Physics.

I AM thus suddenly brought face to face with the second head of my subject: the mathematical and philosophical state of the physical sciences.

The luminiferous ether and the undulatory theory of light have always troubled what is supposed to be the imperturbable character of the mathematics. The proof of a theory is indisputable when it can predict consequences, and call successfully upon the observer to fulfill its prophecies. It is the boast of astronomers that the law of gravitation thus vindicates itself. The undulatory theory of light has shown a wonderful facility of adaptation to each new exigency in optics, and has opened the eye of observation to see what might never have been discovered without the promptings of theory. But this doctrine, and that of gravitation also, have more than once been arrested in their swift march and obliged to show their credentials. After Fresnel and Young had secured a firm foothold for Huyghens's theory of light in mechanics and experiment, questions arose which have perplexed, if not baffled, the best mathematical skill. How is the ether affected by the gross matter which it invests and permeates? Does it move when they move? If not, does the relative motion between the ether and other matter change the length of the undulation or the time of oscillation? These queries cannot be satisfactorily answered by analogy, for analogy is in some respects wanting between the ether and any other substance. Astronomy says that aberration cannot be explained unless the ether is at rest. Optics replies that refraction cannot be explained unless the ether moves. Fresnel produced a reconciliation by a compromise. The ether moves with a *fractional* velocity large enough to satisfy refraction, but too small to disturb sensibly the astronomer's aberration. In 1814, Arago reported to Fresnel that he found no sensible difference in the prismatic refraction of light, whether the earth was moving with full speed toward a star or in the opposite direction, and asked for an explanation. Fresnel submitted the question to mathematical analysis, and demonstrated that, whatever change was produced by the motion of the prism in the relative velocity of light, the wave-length in the prism, and the refraction, was compensated by the physiological aberration when the rays emerged. Very recently, Ketteler, of Bonn, has

[1] Retiring Address before the American Association for the Advancement of Science at the Hartford meeting, August 14, 1874, by the ex-President.

gone over the whole ground again with great care, studying not only Arago's case but the general one, in which the direction of the light made any angle with the motion of the earth; and he proves that the light will always enter the eye in the same apparent direction as it would have done if the earth were at rest. The mathematical and physical view taken of this subject by Fresnel has been under discussion for sixty years, and forty eminent physicists and mathematicians might be enumerated who have taken part in it. Fresnel's explanation has encountered difficulties and objections. Still, it is consistent not only with Arago's negative result, but with the experiments on diffraction by Fizeau and Babinet, and the preponderance of mathematical evidence is on that side. Mr. Huggins runs counter to the general drift of physical and algebraical testimony (although he appears to be sustained by the high authority of Maxwell), when he attributes some displacement of the spectrum-lines to the motion of the earth, and qualifies the observed displacement on that account. The number of stars which Huggins has observed is insufficient for any sweeping generalization. And yet he seems inclined to explain the revelations of his spectroscope, not by the motion of the stars, but by that of the solar system; because those stars which are in the neighborhood of the place in which astronomers have put the solar apex are moving, apparently, toward the earth, while those in the opposite part of the sky recede. If it be true that the earth's annual motion produces no displacement in the spectrum, then the motion of the solar system produces none. Or, waiving this objection, if the correct explanation has been given by Huggins, astronomers have failed, by their geometrical method, of rising to the full magnitude of the sun's motion. The discrepancy appears to awaken no distrust in Mr. Huggins's mind as to the delicacy of the spectrum analysis or the mathematical basis of his reasoning. On the contrary, he would remove the discrepancy by throwing discredit on the estimate of star-distances made independently by Struve and Argelander from different lines of thought.

Next, we ask, if it is certain that even the motion of the luminary will change the true wave-length, the period of oscillation, and the refrangibility, of the light which issues from it. The commonly-received opinion on this subject has not been allowed to pass unchallenged. It is fortified by more than one analogy; but it is said that comparison is not always a reason. It is not denied that, when the sonorous body is approaching, the sound-waves are shortened, the number of impulses on the ear by the condensed air is increased, and the pitch of the sound is raised. Possibly, the color of light would follow the same law; but there is no experiment to prove it, and very little analogy exists between the eye and the ear. There is no analogy, whatever, between the subjective sensation by either organ and the physical action of the prism. The questions at issue are these: Does refraction depend

upon the absolute or the relative velocity of light; are the time of oscillation of the particles of ether and the normal wave-length, corresponding to it, changed by any motion of translation in the origin; or is the conservation of these elements an essential attribute of the luminiferous medium? It has been said that Doppler reasoned as if the corpuscular theory of light were true, and then expressed himself in the language of undulations. Evidently there is an obscurity in the minds of many physicists, and an uncertainty in all, when they reason upon the mechanical constitution of the ether, and the fundamental laws of light. The mathematical theory is not so clear as to be able to dispense with the illumination of experiment. Within the present year, Van der Willigen has published a long and well-considered memoir on the theoretical fallacies which vitiate the whole of Huggins's argument for the motion of the stars and nebulæ. His analysis proves that the motion of the luminary will not interfere with the time of oscillation and the wave-length, provided that the origin of the disturbance is not a mathematical point but a vibrating molecule, and that the sphere of action of this molecule upon surrounding molecules is large enough to keep them under its influence during ten or a hundred vibrations, before it is withdrawn by the motion of translation. If this theoretical exposition of the subject should be generally adopted by mathematicians, the spectroscopic observations on the supposed motion of the stars must receive another interpretation. On the other hand, if a luminary is selected which is known to move, independently of spectroscopic observations, and the displacement of the spectrum-lines accords with this motion, it will be time to reconsider the mathematical theory, and make our conceptions of the ether conform to the experiment. The spectroscopic observation of Angström on an oblique electric spark does not favor Huggins's views. Secchi testifies to opposite displacements when he examined, with a direct-vision spectroscope, the two edges of the sun's equator, one of which was rotating toward him and the other from him, and Vogel has repeated the observation with a reversion spectroscope. This would have the force of a crucial experiment, were it not that an equal displacement was seen on other parallels of latitude, and that the bright bands of the chromosphere were moved, but not the dark lines of the solar atmosphere.

When Voltaire visited England in 1727, he saw at the universities the effect of Newton's revolutionary ideas in astronomy. The mechanism of gravitation had exiled the fanciful vortices of Descartes, which were still circulating on the Continent. So he wrote: "A Frenchman who comes to London finds many changes in philosophy as in other things: he left the world full, he finds it empty." The same comparison might be made now, not so much between nationalities as between successive stages of scientific development. At the beginning of this century the universe was as empty as an exhausted receiver: now it

has filled up again. Nature's abhorrence of a vacuum has been resuscitated, though for other reasons than those which satisfied the Aristotelians. It is the mathematicians and not the metaphysicians who are now discussing the relative merits of the *plenum* and the *vacuum*. Newton, in his third letter to Bentley, wrote in this wise: "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance, through a *vacuum*, without the mediation of any thing else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it." Roger Cotes, who was Newton's successor in the chair of Mathematics and Natural Philosophy at Cambridge, was only four years old when the first edition of the "Principia" was issued, and Newton outlived him by ten years. The venerable teacher pronounced upon the young mathematician, his pupil, these few but comprehensive words of eulogy: "If Cotes had lived, we should have known something." The view taken of gravitation by Cotes was not the same as that held by his master. He advocated the proposition that action at a distance must be accepted as one of the primary qualities of matter, admitting of no further analysis. It was objected by Hobbes and other metaphysicians, that it was inconceivable that a body should act where it was not. All our knowledge of mechanical forces is derived from the conscious effort we ourselves make in producing motion. As this motion employs the machinery of contact, the force of gravitation is wholly outside of all our experience. The advocates of action at a distance reply that there is no real contact in any case, that the difficulty is the same with the distance of molecules as that of planets, that the mathematics are neither long-sighted nor short-sighted, and that an explanation which suits other forces is good enough for gravitation.

Comte extricated himself from this embarrassment by excluding causes altogether from his positive philosophy. He rejects the word attraction as implying a false analogy, inconsistent with Newton's law of distance. He substitutes the word gravitation, but only as a blind expression by which the facts are generalized. According to Comte's philosophy, the laws of Newton are on an equality with the laws of Kepler, only they are more comprehensive, and the glory of Kepler has the same stamp as that of Newton. Hegel, the eminent German metaphysician, must have looked at the subject in the same light when he wrote these words: "Kepler discovered the laws of free motion; a discovery of immortal glory. It has since been the fashion to say that Newton first found out the truth of these rules. It has seldom happened that the honor of the first discoverer has been more unjustly transferred to another." Schelling goes further in the same direction: he degrades the Newtonian law of attraction into an empirical fact, and exalts the laws of Kepler into necessary results of our ideas.

Meanwhile, the Newtonian theory of attraction, under the skillful generalship of the geometers, went forth on its triumphal march through space, conquering great and small, far and near, until its empire became as universal as its name. The whirlpools of Descartes offered but a feeble resistance, and were finally dashed to pieces by the artillery of the parabolic comets; and the rubbish of this fanciful mechanism was cleaned out as completely as the cumbrous epicycles of Ptolemy had been dismantled by Copernicus and Kepler. The mathematicians certified that the solar system was protected against the inroads of comets, and the border warfare of one planet upon another, and that its stability was secure in the hands of gravitation, if only space should be kept open, and the dust and cobwebs which Newton had swept from the skies should not reappear. Prophetic eyes contemplated the possibility of an untimely end to the revolution of planets, if their ever-expanding atmospheres should rush in to fill the room vacated by the maelstroms of Descartes. When it was stated that the absence of infinite divisibility in matter, or the coldness of space, would place a limit upon expansion, and, at the worst, that the medium would be too attenuated to produce a sensible check in the headway of planets; and when, in more recent times, even Encke's comet showed but the slightest symptoms of mechanical decay, it was believed that the motion was, in a practical, if not in a mathematical sense, perpetual. Thus it was that the splendors of analysis dimmed the eyes of science to the intrinsic difficulties of Newton's theory, and familiarity with the language of attraction concealed the mystery that was lurking beneath it. A long experience in the treatment of gravitation had supplied mathematicians with a fund of methods and formulas suited to similar cases. As soon as electricity, magnetism, and electro-magnetism took form, they also were fitted out with a garment of attractive and repulsive forces acting at a distance; and the theories of Cavendish, Poisson, Aepinus, and Ampère, indorsed as they were by such names as Laplace, Plana, Liouville, and Green, met with general acceptance.

The seeds, which were destined to take root in a later generation, and disturb, if not dislodge, the prevalent interpretation of the force of gravitation, were sown by a contemporary of Newton. They found no congenial soil in which they could germinate and fructify until the early part of the present century. At the present moment, we find the luminiferous ether in quiet and undivided possession of the field from which the grosser material of ancient systems had been banished. The *plenum* reigns everywhere; the vacuum is nowhere. Even the corpuscular theory of light, as it came from the hands of its founder, required the reënforcement of an ether. Electricity and magnetism, on a smaller scale, applied similar machinery. If there was a fundamental objection to the conception of forces acting at a distance, certainly the bridge was already built by which the difficulty could be

surmounted. The turning-point between the old physics and the new physics was reached in 1837, when Faraday published his experiments on the specific inductive capacity of substances. This discovery was revolutionary in its character, but it made no great stir in science at the time. The world did not awake to its full significance until the perplexing problem of ocean-telegraphs converted it from a theoretical proposition into a practical reality, and forced it on the attention of electricians. The eminent scientific advisers of the cable companies were the first to do justice to Faraday. This is one of the many returns made to theoretical electricity for the support it gave to the most magnificent commercial enterprise.

The discovery of diamagnetism furnished another argument in favor of the new interpretation of physical action. What that new interpretation was, is well described by Maxwell: "Faraday, in his mind's eye, saw lines of force traversing all space, where the mathematicians saw centres of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a *power* of action at a distance impressed on the electric fluids." The physical statement waited only for the coming of the mathematicians who could translate it into the language of analysis, and prove that it had as precise a numerical consistency as the old view with all the facts of observation. A paper published by Sir William Thomson, when he was an undergraduate at the University of Cambridge, pointed the way. Prof. Maxwell, in his masterly work on electricity and magnetism, which appeared in 1873, has built a monument to Faraday, and unconsciously to himself also, out of the strongest mathematics. For forty years mathematicians and physicists had labored to associate the laws of electro-statics and electro-dynamics under some more general expression. An early attempt was made by Gauss in 1835, but his process was published, for the first time, in the recent complete edition of his works. Maxwell objects to the formula of Gauss because it violates the law of the conservation of energy. Weber's method was made known in 1846; but it has not escaped the criticism of Helmholtz. It represents faithfully the laws of Ampère and the facts of induction, and led Weber to an absolute measurement of the electro-static and electro-magnetic units. The ratio of these units, according to the formulas, is a velocity; and experiment shows that this velocity is equal to the velocity of light. As Weber's theory starts with the conception of action at a distance, without any mediation, the effect would be instantaneous, and we are at a loss to discover the physical meaning which he attaches to his velocity. Gauss abandoned his researches in electro-magnetism because he could not satisfy his mind in regard to the propagation of its influence in time. Other mathematicians have worked for a solution, but have lost themselves in a cloud of mathe-

matical abstraction. The two theories of light have exhausted all imaginable ways in which force can be gradually transmitted without increase or loss of energy. Maxwell cut the Gordian knot when he selected the luminiferous ether itself as the arena on which to marshal the electro-magnetic forces under the symbols of his mathematics, and made light a variety of electro-magnetic action. His analysis gave a velocity essentially the same as that of Weber, with the advantage of being a physical reality and not a mere ratio. Of the two volumes of Mr. Maxwell, freighted with the richest and heaviest cargo, the reviewer says: "Their author has, as it were, flown at every thing: and, with immense spread of wing and power of beak, he has hunted down his victims in all quarters, and from each has extracted something new and interesting for the intellectual nourishment of his readers." Clear physical views must precede the application of mathematics to any subject. Maxwell and Thomson are liberal in their acknowledgments to Faraday. Mr. Thomson says: "Faraday, without mathematics, divined the result of the mathematical investigation; and, what has proved of infinite value to the mathematicians themselves, he has given them an articulate language in which to express their results. Indeed, the whole language of the *magnetic field* and *lines of force* is Faraday's. It must be said for the mathematicians that they greedily accepted it, and have ever since been most zealous in using it to the best advantage."

It is not expected that the new views of physics will be generally accepted without vigorous opposition. A large amount of intellectual capital has been honestly invested in the fortunes of the other side. The change is recommended by powerful physical arguments, and it disenthralls the theories of science from many metaphysical difficulties which weigh heavily on some minds. On the other hand, the style of mathematics which the innovation introduces is novel and complex; and good mathematicians may find it necessary to go to school again before they can read and understand the strange analysis. It is feared that, with many who are not easily deflected from the old ruts, the intricacies of the new mathematics will outweigh the superiority of the new physics.

The old question, in regard to the nature of gravitation, was never settled: it was simply dropped. Now it is revived with as much earnestness as ever, and with more intelligence. Astronomy cast in its own mould the original theories of electrical and magnetic action. The revolution in electricity and magnetism must necessarily react upon astronomy. It was proved by Laplace, from data which would now, probably, require a numerical correction, that the velocity of the force of gravitation could not be less than eight million times the velocity of light; in fact, that it was infinite. Those who believe in action at a distance cannot properly speak of the transmission of gravitation. Force can be transmitted only by matter: either with

it or through it. According to their view, action at a distance *is* the force, and it admits of no other illustration, explanation, or analysis. It is not surprising that Faraday and others, who had lost their faith in action at short distances, should have been completely staggered by the ordinary interpretation of the law of gravitation, and that they declared the clause which asserted that the force diminished with the square of the distance to be a violation of the principle of the conservation of force.

Must we, then, content ourselves with the naked facts of gravitation, as Comte did, or is it possible to resolve them into a mode of action, in harmony with our general experience, and which does not shock our conceptions of matter and force? In 1798, Count Rumford wrote thus: "Nobody surely, in his sober senses, has ever pretended to understand the mechanism of gravitation." Probably Rumford had never seen the paper of Le Sage, published by the Berlin Academy in 1782, in which he expounded his mechanical theory of gravitation, to which he had devoted sixty-three years of his life. In a posthumous work, printed in 1818, Le Sage has developed his views more fully. He supposed that bodies were pressed toward one another by the everlasting pelting of ultra-mundane atoms, inward bound from the immensity of space beyond, the faces of the bodies which looked toward each other being mutually screened from this bombardment. It was objected to this hypothesis, which introduced Lucretius into the society of Newton and his followers, that the collision of atoms with atoms, and with planets, would cause a secular diminution in the force of gravity. Le Sage admitted the fact. But, as no one knew that the solar system was eternal, the objection was not fatal. As the necessity for giving a mechanical account of gravitation was not generally felt at the time, the theory of Le Sage fell into oblivion. In 1873, Sir William Thomson resuscitated and republished it. He has fitted it out in a fashionable dress, made out of elastic molecules instead of hard atoms, and has satisfied himself that it is consistent with modern thermo-dynamics and a perennial gravitation.

Let us now look in a wholly different quarter for the mechanical origin of gravitation. In 1870 Prof. Guthrie gave an account of a novel experiment, viz., the attraction of a light body by a tuning-fork when it was set in vibration. Thomson repeated the experiment upon a suspended egg-shell, and attracted it by a simple wave of the hand. Thomson remarks that "what gave the great charm to these investigations, for Mr. Guthrie himself, and no doubt also for many of those who heard his expositions and saw his experiments, was, that the results belong to a class of phenomena to which we may hopefully look for discovering the mechanism of magnetic force, and possibly also the mechanism by which the forces of electricity and gravity are transmitted." By a delicate mathematical analysis, Thomson arrives at the theorem that the "average pressure at any point of an incom-

pressible, frictionless fluid, originally at rest, but set in motion and kept in motion by solids, moving to and fro, or whirling round in any manner, through a finite space of it," would explain the attractions just described. Moreover, he is persuaded by other effects besides those of light, that, in the interplanetary spaces and in the best artificial vacuum, the medium which remains has "perfectly decided mechanical qualities, and, among others, that of being able to transmit mechanical energy, in enormous quantities:" and he cherishes the hope that his mathematical theorems on abstract hydrokinetics are of some interest in physics as illustrating the great question of the eighteenth and nineteenth centuries: Is action at a distance a reality, or is gravitation to be explained, as we now believe magnetic and electric forces must be, by action of intervening matter?

In 1869 and 1873, Prof. Challis, of Cambridge, England, published two works on the "Principles of Mathematical Physics." They embody the mature reflections of a mathematical physicist at the advanced age of threescore years and ten. Challis believes that there is sufficient evidence for the existence of ether and atoms as physical realities. He then proceeds to say: "The fundamental and only admissible idea of *force* is that of *pressure*, exerted either actively by the ether against the surface of the atoms, or as reaction of the atoms on the ether by resistance to that pressure. The principle of deriving fundamental physical conceptions from the indications of the senses does not admit of regarding *gravity*, or any other force varying with distance, as an essential quality of matter, because, according to that principle, we must, in seeking for the simplest idea of physical force, have regard to the sense of *touch*. Now, by this sense, we obtain a perception of force as pressure, distinct and unique, and not involving the variable element of distance, which enters into the perception of force as derived from the sense of sight alone. Thus, on the ground of simplicity as well as of distinct perceptibility, the fundamental idea of force is pressure." As all other matter is passive except when acted upon by the ether, the ether itself, in its quiescent state, must have uniform density. It must be coextensive with the vast regions in which material force is displayed. Challis had prepared himself for the elucidation and defense of his dynamical theory by a profound study of the laws of motion in elastic fluids. From the mathematical forms in which he has expressed these laws he has attempted to derive the principal experimental results in light, heat, gravitation, electricity, and magnetism. Some may think that Mr. Challis has done nothing but clothe his theory in the cast-off garments of an obsolete philosophy. If its dress is old, it walks upon new legs. The interplay between ether and atoms is now brought on to the stage, not as a speculation supported by metaphysical and theological arguments, but as a physical reality with mathematical supports. I should do great injustice to this author if I left the impression that he himself claimed

to have covered the whole ground of his system by proof. Mathematical difficulties prevented him from reaching a numerical value for the resultant action of a wave of ether upon the atom. What he has written is the guide-post, pointing the direction in which science is next to travel; but the end of the journey is yet a great way off. The repeated protests of Mr. Challis against the popular physics of the day, and his bold proclamation of the native, independent motion of the ether, have aroused criticism. What prevents the free ether, asks the late Sir John Herschel, from expanding into infinite space? Mr. Challis replies that we know nothing about infinite space or what happens there, but the existence of the ether, where our experience can follow it, is a physical reality. The source of the motion which the ether acquires is not the sun; for the most efficient cause of solar radiation is gravitation and condensation. Our author avoids the vicious circle of making gravitation, first the reason and afterward the consequence of the motion of the ether. He says: "It follows that the sun's heat, and the heat of masses in general, are stable quantities, oscillating, it may be, like the planetary motions, about *mean* values, but never permanently changing, so long as the Upholder of the universe conserves the force of the ether and the qualities of the atoms. There is no law of destructibility; but the same Will that conserves can in a moment destroy." The following remarks upon this theory deserve our attention: "The explanation of any action between distant bodies by means of a clearly conceivable process, going on in the intervening medium, is an achievement of the highest scientific value. Of all such actions that of gravitation is the most universal and the most mysterious. Whatever theory of the constitution of bodies holds out a prospect of the ultimate explanation of the process by which gravitation is effected, men of science will be found ready to devote the whole remainder of their lives to the development of that theory."

The hypotheses of Challis and Le Sage have one thing in common: the motion of the ether and the driving storm of atoms must come from outside the world of stars. "On either theory, the universe is not even temporarily automatic, but must be fed from moment to moment by an agency external to itself." Our science is not a finality. The material order which we are said to know makes heavy drafts upon an older or remoter one, and that, again, upon a third. The world, as science looks at it, is not self-sustaining. We may abandon the hope of explaining gravitation, and make attraction itself the primordial cause. Our refuge then is in the sun. When we qualify the conservation of energy by the dissipation of energy, the last of which is as much an induction of science as the first, the material fabric which we have constructed still demands outward support. Thomson calculates that, within the historical period, the sun has emitted hundreds of times as much mechanical energy as is contained in the united

motions of all the planets. This energy, he says, is dissipated more and more widely through endless space, and never has been, probably never can be, restored to the sun, without acts as much beyond the scope of human intelligence as a creation or annihilation of energy, or of matter itself, would be.

From the earliest dawn of intellectual life, a general theory of the constitution of matter has been a fruitful subject of debate, and human science and philosophy have ever been dashing their heads against the intractable atoms. The eagerness of the discussion was the greater, the more hopeless the solution. For every man who set up an hypothesis upon the subject, there were half a dozen others to knock it down; until at last speculation, which bore no fruit, was suspended. A lingering interest still hung around the question, whether matter was not infinitely divisible, and the atomic philosophers were not chasing a chimera. From every new decision on this single point there was an appeal, and the foothold which the atoms had secured in chemistry was gradually subsiding. Of a sudden, the atomic theory has gained a new lease of life. But the hero of the new drama is not the atom, but the molecule. In all the physical sciences, including astronomy, the war has been carried home to the molecules; and the intellectual victories of this and the next generation will be on this narrow field. From the outlying provinces of physics; from the sun, the stars, and the nebulæ; from the comets and meteors; from the zodiacal light and the aurora; from the exquisitely tempered and mysterious ether —the forces of Nature have been moving in converging lines to this common battle-ground, and some shouts of victory have already been heard. In the long and memorable controversy between Newton and Leibnitz, and their adherents, as to the true measure of force, it was charged against the Newtonian rule that force was irrecoverably lost whenever a collision occurred between hard, inelastic bodies. The answer was, that Nature had anticipated the objection, and had avoided this kind of matter. Inelastic bodies were yielding bodies, and the force which had disappeared from the motion had done its work in changing the shape. But, unless the body could recover its original figure by elasticity, there was no potential energy, and force was annihilated. It is now believed, and to a large extent demonstrated, that the force, apparently lost, has been transformed into heat, electricity, or some other kind of molecular motion, of which the change of shape is only the outward sign. The establishment on a firm foundation of theory and experiment of the so-called conservation of energy, the child of the correlation of physical forces, is one of the first fruits of molecular mechanics.

It is no disparagement of this discovery, on which was concentrated the power of several minds, to call it an extension, though a vast one, of Newton's law of inertia, of Leibnitz's *vis viva*, and of Huyghens's and Bernouilli's conservation of living forces; these older

axioms of mechanics having free range only in astronomy, where friction, resistance, and collision, do not interfere. The conservation of energy, in its extended signification, promises to be, like its forerunners, a valuable guide to discovery, especially in the dark places into which physical science has now penetrated. The caution which Lagrange has given in reference to similar mechanical principles, such as the conservation of the motion of the centre of gravity, the conservation of moments of rotation, the preservation of areas, and the principle of least action, is not without its applicability to the new generalization. Lagrange accepts them all as results of the known laws of mechanics, and not as the essence of the laws of Nature. The most that physical science can assert is, that it possesses no evidence of the destructibility of matter or force.

It is not pretended that the existence of atoms has been or can be proved or disproved. Some chemists think that the atomic theory is the life of chemistry; others have abandoned it. Its importance is lost in that of the molecular theory. And what has this accomplished to justify its existence? If we define the molecule of any substance as the smallest mass of that substance which retains all its chemical properties, we can start with the extensive generalization of Avogadro and Ampère, that an equal volume of every kind of matter in the state of vapor, and under the same pressure and temperature, contains an equal number of such molecules. The conception of matter as consisting of parts, which are perpetually flying over their microscopic orbits, and producing by their fortuitous concourse all the observed qualities of bodies, is as old as Lucretius. He saw the magnified symbol of his hypothesis in the motes which chase one another in the sunbeam. One of the Bernouillis thought that the pressure of gases might be caused by the incessant impact of these little masses on the vessel which held them. The discovery that heat was a motion and not a substance, foreshadowed by Bacon, made probable by Rumford and Davy, and rigidly proved by Mayer and Joule when they obtained its exact mechanical equivalent, opened the way to the dynamical theory of gases. Joule calculated the velocity of this promiscuous artillery, rendered harmless by the minuteness of the missiles, and found that the boasted guns of modern warfare could not compete with it. Clausius consummated the kinetic theory of gases by his powerful mathematics, and derived from it the experimental laws of Mariotte, Gay-Lussac, and Charles. By the assumption of data, more or less plausible, several mathematicians have succeeded in computing the sizes and the masses of the molecules and some of the elements of their motion. It should not be forgotten that mathematical analysis is only a rigid system of logic by which wrong premises conduct the more surely to an incorrect conclusion. To claim, for all the conclusions which have been published in relation to the molecules, the certainty which fairly belongs to some of them, would prejudice the whole cause.

One of the most interesting investigations in molecular mechanics was published by Helmholtz in 1858. It is a mathematical discussion of what he calls ring-vortices, in a perfect, frictionless fluid. Helmholtz has demonstrated that such vortices possess a perpetuity and an inviolability once thought to be realized only by the eternal atoms. The ring-vortices may hustle one another, and pass through endless transformations; but they cannot be broken or stopped. Thomson seized upon them as the impersonation of the indestructible but plastic molecule which he was looking for, to satisfy the present condition of physical science. The element of the new physics is not an atom or a congeries of atoms, but a whirling vapor. The molecules of the same substance have one invariable and unchangeable mass; they are all tuned to one standard pitch, and, when incandescent, emit the same kind of light. The music of the spheres has left the heavens and condescended to the rhythmic molecules. There is here no birth, or death, or variation of species. If other masses than the precise ones which represent the elements have been eliminated, where, asks Maxwell, have they gone? The spectroscope does not show them in the stars or nebulæ. The hydrogen and sodium of remotest space are in unison with the hydrogen and sodium of earth.

In the phraseology of our mechanics we define matter and force as if they had an independent existence. But we have no conception of inert matter or of disembodied force. All we know of matter is its pressure and its motion. The old atom had only potential energy; the energy of its substitute, the molecule, is partly potential and partly kinetic. If it could be shown that all the phenomena displayed in the physical world were simply transmutations of the original energy existing in the molecules, physical science would be satisfied. Where physical science ends, natural philosophy, which is not wholly exploded from our vocabulary, begins. Natural philosophy can give no account of energy when disconnected with an ever-present Intelligence and Will. In Herschel's beautiful dialogue on atoms, after one of the speakers had explained all the wonderful exhibitions of Nature as the work of natural forces, Hermione replies: "Wonderful, indeed! Anyhow, they must have not only good memories but astonishing presence of mind, to be always ready to act, and always to act, without mistake, according to the primary laws of their being, in every complication that occurs." And elsewhere, "action, without will or effort, is to us, constituted as we are, unrealizable, unknowable, inconceivable." The monads of Leibnitz and the demons of Maxwell express in words the personality implied in every manifestation of force.

In this imperfect sketch of the increased resources, and the present attitude of the physical sciences, I have not aimed to speak as an advocate, much less to sit as a judge. The great problem of the day is, how to subject all physical phenomena to dynamical laws. With all the experimental devices and all the mathematical appliances of this

generation, the human mind has been baffled in its attempts to construct a universal science of physics. But nothing will discourage it. When foiled in one direction, it will attack in another. Science is not destructive, but progressive. While its theories change, the facts remain. Its generalizations are widening and deepening from age to age. We may extend to all the theories of physical science the remark of Grote, which Challis quotes in favor of his own: "Its fruitfulness is its correctibility." Instead of being disheartened by difficulties, the true man of science will congratulate himself in the words of Vauvenargues, that he lives in a world fertile in obstacles. Immortality would be no boon if there were not something left to discover as well as to love. Fortunate, thought Fontenelle, was Newton, beyond all other men, in having a whole fresh universe before him, waiting for an explanation. But science wants no Alexanders weeping because there are not other worlds to conquer. For every heroic Columbus who launches forth, in however frail a bark, upon untried oceans, seeing before him rich continents where others behold only a wilderness of waters, there are precious discoveries in reserve. Surely the time has not yet come when the men in any section in this Association can fold their arms and say, "It is finished." Unless our physicists are contented to lag behind and gather up the crumbs which fall from the rich laboratories and studies of Europe, they must unite to delicate manipulation the power of mathematical analysis. Mathematics wins victories where experiment has been beaten. With good reason we applaud the many brilliant successes of instrumental research. Mathematical analysis, with its multitudinous adaptations, is the only key which will fit the most intricate wards in the treasury of science. With the help of her mathematical physicists, Great Britain has now taken a position in science which she has not held before since the days of Newton. In Germany, the physicists do not hold back from the most difficult problems of the day, because they are led along by experiment on one arm and by mathematics on the other. The zeal of the Italian scientists prevails over even the terrors of Vesuvius, and makes them ready to become martyrs, like Pliny the Elder, to Nature and humanity. France, too, out of the very ashes of her humiliation, sends an inspiring word to us. Since her defeat, her scientific spirit has been aroused as it was after the days of the first Revolution. Her Association for the Advancement of Science is only a two-year-old infant; but it has sprung into existence, like Minerva from the head of Jupiter, full grown and equipped. Already it has displayed a vitality and a prosperity which this Association, in its opening manhood, has not yet acquired. The words of its first president are as true for the United States as for France—that the strength and glory of a country are not in its arms, but in its science.

REASON AGAINST ROUTINE IN THE TEACHING OF LANGUAGE.

FROM THE FRENCH OF CLAUDE MARCEL.

PART I.—*What Reason prescribes.*

TWO DIFFERENT CLASSES OF LANGUAGES.—The mode of teaching living and dead languages is nearly the same. The differences between these two classes of languages, and the ends sought in studying them, need to be better defined.

Living languages, like the mother-tongue, are simple instruments which cannot be too soon mastered for instruction in our own social relations, and information of the political, scientific, and industrial life of other people. But dead languages are not the depositories of science, nor do they serve for the exchange of ideas; they are studied solely for the intellectual development they favor.

A professor of Greek or Latin, who knows to its foundations the language of his pupils, in teaching the ancient language, can give them critical and rational instruction—can call into exercise their highest faculties. But a foreigner, teaching his own language, rarely learns the niceties of the French, and seldom knows it as well as his pupils. He cannot, therefore, in any way, use their own language to aid them in learning his; so he only attempts to give them a practical knowledge of it. Hence the methods of studying these two classes of languages should differ essentially. Exercises in the ancient languages should be a gymnastic of the mind resulting from their comparison with the national idiom; each lesson in Latin being also a lesson in French. Exercises in modern languages should be vehicles of thought without the intervention of the national idiom, and they should be so familiar as to become, through reading and hearing, sources of natural instruction.

The complete knowledge of a language includes four distinct arts—reading, hearing, speaking, writing. In an ancient language we need only the first of these arts. Its study should have no aim but that of giving the pupils the ability to read the classical authors, and appreciate the charm of their compositions. It is in meditating on the thoughts of the great writers of antiquity, and in translating their masterpieces, that we discover their beauties, and are able to transfer them into our native language.

In living languages these four arts should be the object of study. To say that one class of languages is learned to be spoken, and the other class to be read, does not express the exact difference of aim in the two cases. The art of speaking is useless unless we understand what is said, and this talent of understanding is a hundred times more

useful than that of speaking. The same is also true of reading, for we rarely have occasion to speak foreign languages, while we may read them daily with profit. In reading, as in listening, we always learn something, and especially the language. In speaking we learn nothing, not even the language; the mind is not enriched with a word or an idea. The habit of following, in reading and hearing, the logical connection of ideas which characterizes serious discourse, forms the mind to all modes of reasoning, to all kinds of argument. But the habit of speaking, to the exclusion of listening and reading, implies a loss of judgment. The least instructed are often those who talk the most. It was not by speaking French, but by reading it, that the Prussians learned what they needed to know to insure their success against us.

It is infinitely more useful to read modern than ancient languages. The latter are seldom read after the period of school; but we read the former throughout life, not only for the intellectual pleasure they afford, but to gather knowledge needed in the professions and in our social relations.

Order of Study for a Living Language.—The child learns successively the four arts of his language. He first seizes the phraseology that interprets to him the language of action which accompanies the first words addressed to him. Gestures, expressions of the face, tones of the voice, are equivalent to phrases, not to words. So he understands the sense of phrases long before the words that form them. By the aid of these natural signs the infant listens and understands, then he imitates and speaks. It is only when articulate sounds awaken in his young intelligence the ideas of which they are the signs, that he seeks to reproduce them as he heard them. He owes his progress to example, not to precept; to practice, not to theory. Such is the method of Nature, admirable in simplicity and infallible in results. The nearer we come to it the surer will be our success.

Articulate and written words, the signs of ideas, being conventional, we can apply them justly only so far as we have received the impression associated with the ideas they represent, only so far as they are made familiar by the habit of reading and listening. In other words, the double talent of understanding the written and spoken foreign language conduces respectively to the arts of writing and speaking. Just as in learning our native tongue, it is by the judicious exercise of imitation founded on this double talent that we easily acquire the arts of speaking and writing. On this point the laws of our constitution and the nature of language are profoundly in accord.

In fact, we possess, as means of improvement, two powerful instincts, *curiosity* and *imitation*, which urge us ever toward the end Providence has assigned, and assure our success in the acquisition of language. Curiosity is the source of progress in the arts of reading and listening; imitation, which comes after curiosity, is the source

of progress in the arts of speaking and writing. The duty of the professor is wisely to stimulate and direct these admirable instincts of his pupils.

In order, then, to conform to the rules of Nature, we should commence the study of a foreign language by reading and listening, which enriches the mind with ideas and knowledge, and at the same time puts it in possession of the corresponding phraseology. At the Lyceum this plan is reversed. Without regarding this innate desire to know, to gather ideas, we occupy the young with words by prematurely directing their attention to the arts of speaking and writing. The mind is not nourished, it is hindered, and in its turn it refuses that which is imposed upon it; or it is enfeebled under an irksome and unproductive labor. If so many young people are indolent and unwilling to study, it is because they are weighed down with lessons and duties repugnant to them: we distort Nature, and do violence to their instincts.

The art of reading a foreign language should be the first in the order of study, as it is the basis on which acquisition of the other three reposes. Besides being easier, more accessible, and attainable without a master, it surpasses them all in the number and importance of the advantages it presents. We derive the greatest benefit from it in the ordinary circumstances of life. We can practise it in all times and places, at home or abroad, whether for profit or pleasure, and so never forget it. It furnishes the means of studying the phraseology and deducing the laws of language, and only by means of it are we made acquainted with the doings of other nations.

The art of listening is the second in importance; it is the best part of conversation. Like reading, it satisfies the instinctive love of knowledge. If we perfectly understand what is said to us, a few words, a monosyllable, suffices to sustain conversation. This art demands a special exercise all the more, as listening is the true and only means of acquiring pronunciation. The vocal power is entirely under the government of the ear. At the Lyceum, not an hour is given to this exercise in all the course of study. How few persons, after four or five years of English in class, can understand Englishmen when speaking their language, and how few can pronounce English correctly!

In the vernacular, we pass from hearing to reading. It is spoken language, the first manifestation of our thought, which gives us the key to written language. In the same way, but in an inverse order, those who learn a language in books should often hear the written text, to familiarize themselves with the pronunciation and to recognize the written words in the spoken words. Their progress in understanding the spoken language will be much more rapid, if they comprehend the written language without translating it.

Reading is *direct* or *indirect*. In direct reading, the written expression recalls the thought, as in reading our mother-tongue. In indirect reading we arrive at the idea by the aid of the mother-tongue,

that is, by translation. To read a foreign language directly is to think in that language: translation is thinking in our own.

When we have, for a long time, seen in books and heard in the talk of the master words associated directly with the ideas they represent, we have no difficulty in reproducing the orthography and pronunciation, the first elements of writing and speaking. The phraseology thus insensibly engraved upon the mind by repetition becomes one with the thought.

However, inconceivable as it seems, it is insisted that the principal object of studying a living language is, to be able to speak it. From this popular error, from this false point of departure, proceed almost all the methods in vogue. They aim, for the most part, exclusively at the acquisition of this art. Despising the order and the wise slowness of Nature, they break the chain which binds together the great purposes of language, neglect direct reading—the inexhaustible source of instruction and intellectual enjoyment—and listening—the most useful part of conversation—and of necessity resort to processes little in harmony with our organization and the nature of language.

Grammar, exercises, reading aloud, and mnemonic lessons, mere word-practice—the sole resource in teaching to write and speak a foreign language—do not help in the least in learning to read and understand it, nor even in learning to speak and write it, for lack of imitation, by which means alone these arts are acquired. This, it is true, is no great evil, for, out of a hundred people who learn to speak and write, there are not two, perhaps, who ever have serious occasion to use their knowledge. But what pains for nothing! what a loss of time!

Processes and Results.—The art of reading English, for example, is acquired rapidly, without groping, and without error, by taking for the first lessons familiar subjects treated in simple language, as free as possible from idioms, but strictly conformed to usage and to grammar; the French text, equally free from idioms, being placed on the opposite page. The triviality of the language in the first books is, in the end, no hindrance to progress. The best writers, the greatest orators, have begun with puerilities and commonplaces in learning their own language, and it will be the same in another if we assiduously read good authors.

Based on the truth that a student can translate only what he understands, the interpretation on the opposite page presents to him the thought of the foreign text: he passes, phrase by phrase, from the interpretation to the text, that is, from the known idea to the unknown words. Without pronouncing, he reads the French on the English—attaches to each English word the corresponding French word. In accordance with reason, he proceeds from the phrase to the words, from the idea to the sign. This translation is preferable to the use of a dictionary, because it faithfully renders the thought of the author.

It plays the same part as the language of action in the mother-tongue. In thus conforming to the law of Nature, by which we pass from the whole to its parts, this process saves the student from uncertainty and *ennui* in the understanding of authors, and he will naturally use it in reading outside of his lessons. The promptitude with which the pupil, by this method, seizes the thought of the author, gives an interest to the reading which cannot be attained when the attention is arrested on each word, and all connection of ideas destroyed by the use of a dictionary. Besides, in this way the pupil reads more in a given time, the same expressions recur oftener, and so are engraved upon the memory. Progress in reading is in inverse ratio to the time taken. For example, 100 pages translated at the rate of ten pages a day advances the student more in the art of reading than the same 100 pages read at the rate of one page a day.

My first reading-books of English are formed on this plan. Composed of anecdotes and familiar recitals that pique the curiosity, they are, so to speak, *practical vocabularies*, of which all the words have a determined meaning; they address the understanding as well as the memory. The reading again and again of the same passages impresses the words, with their terminations, upon the mind with more certainty than the mechanical learning by heart in grammars, vocabularies, and phrase-books, of the current methods.

Led by the interest of the subject, each sentence awakens a desire to understand the next, and to pursue the reading, while nothing is more fatiguing and discouraging than the work of reading disconnected phrases. The student will have only to read a few volumes with the translation on the opposite page, before he can translate good authors without this auxiliary. After this, the sense of the new words he encounters will be easily discovered from the context, or by the aid of the dictionary, and he will soon read the authors directly. From this moment he will progress in all the other parts of the study.

To free himself entirely from the translation, the student must read the same passages many times: he then seizes the sense more rapidly, and ideas associate themselves naturally with words. He must, above all, read the entire work. In proportion as he advances in reading a book, it becomes easier, while the same subject, the same style, remaining longer under the attention, the phraseology of the author will be more profoundly impressed on the mind, and will be more closely linked to the thought. The stories of which the first books of this method are composed belong to common language, and contain the words and phrases ordinarily employed, so that they familiarize the student with the most useful elements of conversation and correspondence.

The facility with which a pupil reads and the rapidity of his progress permit him to read more in three months than in three years by other methods. Those who object to this facility of work, con-

demn Nature; for the learning of the mother-tongue is so easy that it is acquired without any hesitation. Besides, this rapid progress leaves the student time for other studies.

Pupils who study alone are limited to written language, but with a master the spoken language may be entered upon by means of exercises in listening. By attention to the reading of the master, the art of understanding foreign speech is acquired even more rapidly than the art of reading; because the elements of language being very limited, they are frequently revived, and the association of the pronunciation with the written word is easily made. In this way an adult would be able in a year or eighteen months, in his own country, without *ennui* or effort, to learn to understand the written or spoken language as perfectly as the foreigners themselves; but never in the same circumstances would he be able to speak it as they do.

Children, by this rational method, could early learn a living language, and be in full possession of these two arts, which would serve conjointly with the mother-tongue in their other studies. As to the arts of speaking and writing, they cannot hasten acquisition, and they will be forgotten long before there is occasion to use them. Direct reading, on the contrary, far from being forgotten, will become by practice a habit of the mind, and, when the pupils leave the Lyceum, their knowledge of English and German will be powerful auxiliaries in the other careers to which they are destined, and they will be able through life, by the aid of the periodic press and new publications, to keep acquainted with all that is published by neighboring people.

The little time and expense involved in learning to read a foreign language, by means of translations on the opposite page, as well as the facility with which it is done, will be sufficient motives to make it an object of the higher primary instruction. Peasants need neither to listen, to speak, nor to write a foreign language; reading alone suffices them. The reading aloud of the mother-tongue, taught to children in the primary schools, without stimulating the curiosity or developing the taste for reading, leaves them all their lives with intelligence as limited, and in an ignorance as profound, as if they could not read at all. Such varied and extended reading as this method proposes, creates a taste for reading, and a desire to understand, without which the art of reading is worthless.

The International Exchange of Thought.—The twofold talent of reading and understanding, the most important in international relations, may be acquired by the humblest; since the first can be learned without a master, and the second requires only the services of a reader for a few weeks. Their acquisition is so easy and so rapid, when their study is taken out of the grooves of routine, that a pupil would be able, without neglecting any of the usual studies, to learn and understand half a dozen languages in less time than it would take to learn to speak and write a single one easily and correctly. It is so

difficult to speak a foreign language, that in most cases recourse to this art materially hinders international exchange of ideas.

The order of studies in our lyceums inverts the order I have recommended. The university imposes written exercises in composition for the living languages, from the lowest classes to the highest. Imagine a French officer, *strong* in this department, in the country of an enemy, whose language when spoken he cannot understand. In his impotence to gather useful intelligence, what can he do but deplore the false direction given to his studies, and curse the incomplete teaching of the college? The attention of the young should be particularly directed to the arts of reading and hearing, which, if universally diffused, would alone suffice for the international exchange of thought. People of different nations, each speaking or writing his own tongue, would understand each other. Their conversation or correspondence would be every way much more intimate and satisfactory, when each used his mother-tongue, with the native freedom and clearness that he could not attain in a foreign language. In this way would be secured the great *desideratum* of modern society—the means of international communication.

By endowing youth with the ability to understand a foreign language when spoken, those who travel could, on reaching a country, enjoy the society of the inhabitants, mix in the movements of science, listen to the lessons of celebrated masters, and, in completing their scientific education, establish useful relations for life.

If the art of listening, a necessity of modern times, should take root in the schools of all civilized countries, it would second wonderfully the high aspirations of humanity. Never, more than now, have people felt the need of solidarity and fraternity; the mind of the century presses toward union in congresses, and associations for the discussion of important social, scientific, and political questions.

Mental Culture. — It is known that ancient literature offers models of composition, which aid, when studied, in forming and purifying the taste; while at the same time it cultivates observation and reflection by the analysis of thoughts and facts relative to an order of things above the realities of sense. But I shall not cease to repeat that, to obtain these results, the authors must be read *directly*. This acquisition should be the object of the first period of study. In the second period, critical teaching of the literature of these languages, if combined with profound study of the national idiom, will aid powerfully in the development of the intelligence.

As a means of cultivating the higher faculties of the mind, direct reading of the solid works of great writers, ancient and modern, is of indisputable efficacy. It is, in fact, a true *logique practique*. But the art of reading by free translation presents inestimable advantages, which cannot be obtained from any other branch of instruction, nor from a language of which only the first elements are known. Being

able to enter into the spirit of the foreign text, the student easily seizes the relation between thought and its expression, and the analysis of the expression, needed to render it into French, becomes an intellectual exercise, which brings to his knowledge the genius of two languages and two peoples. If he translates a good author, he forms the habit of expressing in French only just ideas. He rises to the height of the author by appropriating his thoughts: his own conceptions become more clear by the effort he makes to express them clearly. He thus forms a good style, in trying to reproduce in his translation the qualities of the original.

Independently of its special use in giving power of expression, translation is an indisputable source of progress in mental culture. Correct expression and correct thinking are one and the same. Great eloquence implies high intelligence. The act of mind by which a student assures himself of the exact sense of the foreign text, and the search for expressions which shall better render the thought of the author, are operations of high intellectual import. They aid him to express his meaning, to analyze it, and to state it neatly in his judgments and reasonings.

In the efforts of a translator to render the original clearly, precisely, and conformably to the genius of his language, he corrects, expands, condenses his phrases, examines them under the relations of style and meaning. He reflects, observes, compares, judges, chooses understandingly, weighs the import of terms and reasonings, and appeals to analogy, to his recollections, and his own experience. It is this necessity of a complex action of the mind which is the principal merit of classical and literary study.

Some modern languages, as English and German, are rich in works which rival those of antiquity in force, clearness, and grace of expression, while imparting much more by the positive knowledge they contain. They might profitably replace the classics, but they would have to be taught by the French; and then, on the other hand, pupils would have small chance of being able ever to understand and read them like the English and Germans.

It is clear that, for this intellectual gymnastic, the language must be read directly. By so much as one falls short of this, he cannot derive advantage from the reading. In the first exercises of translation, whether we pass from the phrase to the word by the way of reason, or from the word to the phrase by the way of routine, we can neither take in the full import of the text, nor enter into the spirit of the author. We should seek the promptest means to free ourselves from oral translation, which is best done by means of the translation on the opposite page.

Translation, as ordinarily practised, not as an exercise in French composition, but to construe the authors, violates the law of Nature, which requires that we pass from the phrase to the words. In our

native tongue we know the precise sense of words only by the phrases in which they occur; taken separately, they have no determined meaning. A phrase cannot be translated unless it is comprehended, and, to secure this comprehension, we make the translation for the student by employing words to which he attaches no precise idea! How could the mind develop under such a muddle of a system?

THE ART OF SPEAKING A FOREIGN LANGUAGE IN PUBLIC SCHOOLS.—Not having determined in a precise manner the relative importance of the objects proposed in learning a language, the means are confounded with the end. To persevere a long time in translation, whether to understand the language, to speak it, or to write it, is to form a habit which excludes the possibility of thinking in that language, and retaining the phraseology for use in conversation.

In the absence of classification, and of principles known to be in harmony with the constitution of man and the nature of language, the true objects of study are forgotten, and the order which facilitates acquisition is reversed. Pedagogy based on a knowledge of principles is unhappily a science little known, and generally ignored by teachers and professors.

The natural application of these principles to the acquisition of our native language offers us an infallible guide and simple processes of marvelous efficacy. By what perversity or blindness are we kept from the route traced for us by Nature? Why not avail ourselves of those powerful instincts, curiosity and imitation—especial sources of progress in the acquisition of language? Providence has given them to man to accomplish his destiny. It is an aberration of the human mind, it is almost an impiety, to reject them and seek other means for learning a second language.

Most authors of new methods make, it is true, the pretense of following Nature in their processes; but this is an illusion. Besides, they disagree among themselves, and consequently cannot all be true. Truth is ONE. There are not two ways of imitating Nature in attaining a particular end. All these methods and those of the university have this in common, that, in direct opposition to the laws of our organization, and the nature of language, they pretend to teach the speaking and writing of a foreign language, without depending upon reading and listening—without even making the least allusion to the necessity of thinking in that language. While public instruction perseveres in this false way, no young man will speak English or German on leaving college. He might be able, perhaps, in unconnected conversation, to pronounce some commonplace phrases, but he will not converse in the true meaning of the word.

The minister wishes that, after a little time, the classes should talk with their teacher in English and German; but what conversation can there be with professors, mostly foreigners, while the scholars are yet in the rudiments? The little they will have to say, which always

relates to the lesson—a very limited subject—would never give sufficient practice to enable them really to speak the language. They find themselves together: the professor to give, the pupils to receive instruction. The teacher talks to them in a language they know perfectly well; they listen, and say nothing.

A general conversation outside the lesson would be less practicable. There is nothing in common between the professor and his pupils. There are no subjects, or they are always the same. But it is more than probable that, if, in the presence of thirty or forty pupils little versed in the foreign language, he should speak this language, and seek to make them speak it, all his efforts would produce only confusion, disobedience, and disorder. At best, this chit-chat could only take place in private instruction.

On the other hand, the difficulty of pupils in understanding the master, and the frequent correction of their errors, would constantly draw away the attention from the subject to discuss words; would discourage the pupils and fatigue the master, and make all genuine conversation impossible. But what time would thirty or forty pupils have to converse, in the three hours a week that is granted, even though they did nothing but converse all the time? Each one, if they took turns, would have *four minutes a week!*

The arts of speaking and writing are acquired without difficulty, if, conforming to the laws of Nature, pupils read and listen beforehand, and always associate the idea with the word. When they perfectly understand the spoken language, the professor can address his class in it, so that each lesson will be, for all, an advance toward the desired end. To listen, and understand what is said, is to learn to pronounce and to talk. Later, the book first used in reading and listening will teach, by imitation, the arts of speaking and writing. Recurring to example instead of rules, the pupils will take their phraseology as a model, and vary it infinitely in expressing their own thoughts.

EMOTIONS IN THE PRIMITIVE MAN.

By HERBERT SPENCER.

A MEASURE of evolution in living things is, the degree of correspondence between changes in the organism and coexistences and sequences in the environment. In the "Principles of Psychology," it was shown that mental development is "an adjustment of inner to outer relations that gradually extends in Space and Time, that becomes increasingly special and complex, and that has its elements ever more precisely coördinated and more completely integrated." Though in that place chiefly exemplified as the law of in-

tellectual progress, this is equally the law of emotional progress. The emotions are compounded out of simple feelings, or rather out of the ideas of them; the higher emotions are compounded out of the lower emotions; and thus there is progressing integration. For the same reason there is progressing complexity: each larger consolidated aggregate of ideal feelings contains more varied, as well as more numerous, clusters of components. The extension of the correspondence in Space, too, though less manifest, may still be asserted: witness the difference between the proprietary feeling in the savage, responding only to a few material objects adjacent to him—weapons, decorations, food, place of shelter, etc.—and the proprietary feeling in the civilized man, who owns land in Canada, shares in an Australian mine, Egyptian stock, and mortgage-bonds on an Indian railway. And, that the extension of the correspondence in Time may be asserted of the more-evolved emotions will be manifest, on remembering how the sentiment of possession is gratified by acts of which the fruition can come only after many years, and even gets pleasure from an ideal power over bequeathed property; and on remembering how the sentiment of justice seeks satisfaction in reforms that are to benefit future generations.

As pointed out in a later division of the "Principles of Psychology," a more special measure of mental development is the degree of representativeness in the states of consciousness. Cognitions and feelings were both classified in the ascending order of presentative, presentative-representative, representative, and re-representative. This general order has been necessary; since there must have been presentation before representation, and representation before re-representation. It was shown, too, that this more special standard harmonizes with the more general standard; since increasing representativeness in the states of consciousness is shown by the more extensive integrations of ideas, by the greater definiteness with which they are represented, by the greater complexity of the integrated groups, as well as by the greater heterogeneity among their elements; and here it may be added that greater representativeness is also shown by the greater distances in space and time to which the representations extend.

There is a further measure which may be serviceably used along with the other two. As was shown in the "Principles of Psychology:"

"Mental evolution, both intellectual and emotional, may be measured by the degree of remoteness from primitive reflex action. The formation of sudden, irreversible conclusions on the slenderest evidence is less distant from reflex action than is the formation of deliberate and modifiable conclusions after much evidence has been collected. And similarly, the quick passage of simple emotions into the particular kinds of conduct they prompt is less distant from reflex action than is the comparatively-hesitating passage of compound emotions into kinds of conduct determined by the joint instigation of their components."

Here, then, are our guides in studying the primitive man as an emotional being. Considering him as less evolved, we must expect to find him comparatively wanting in those most complex emotions that respond to multitudinous and remote probabilities and contingencies. His consciousness may be regarded as unlike that of the civilized man, by consisting in a greater degree of sensations and the simple represented feelings directly associated with them, and by containing fewer and weaker feelings involving representations of consequences beyond the proximate. And the relatively-simple emotional consciousness thus characterized we may expect to be consequently characterized by less of that coherence and continuity which results when the promptings of direct desires are checked by sentiments responding to ultimate effects, and by more of that irregularity which results when each desire as it arises discharges itself in action before counter-desires have been awakened.

On turning from these deductions to examine the facts with a view to induction, we meet difficulties like those which we met in the last chapter. As in size and structure the inferior races differ from one another enough to produce some indefiniteness in our conception of the primitive man—physical; so in their passions and sentiments the inferior races present contrasts sufficiently marked to obscure the essential traits of the primitive man—emotional.

This last difficulty, like the first, is indeed one that might have been anticipated. The spreading of the race during all past epochs into the multitudinous widely-contrasted habitats entailing widely-unlike modes of life has necessarily been accompanied by emotional specialization as well as by physical specialization. And beyond differentiations of character directly due to differences of natural circumstances and resulting habits, the inferior varieties of men have been made to differ by the degrees and durations of social discipline they have been subject to. Referring to such unlikenesses, Mr. Wallace remarks that "there is, in fact, almost as much difference between the various races of savage as of civilized peoples."

To conceive the primitive man, therefore, as he existed when social aggregation commenced, we must generalize as well as we can this entangled and partially-conflicting evidence: led mainly by the traits common to the very lowest, and finding what guidance we may in the *a priori* conclusions set down above.

The fundamental trait of impulsiveness, though one to be looked for as universal among inferior races, is not everywhere conspicuous. Taken in the mass, the aborigines of the New World seem impassive in comparison with those of the Old World: some of them, indeed, exceeding the civilized people of Europe in ability to control their emotions. Through stories most peoples have been made familiar with this trait of the North-American Indians; and the statements of

recent travelers confirm those of older ones. The Dakotas are said to suffer with patience both physical and moral pains. The Creeks display "phlegmatic coldness and indifference." So, too, with various native peoples of South America. According to Burnand, the Guiana Indian, though "strong in his affections," will lose his dearest relations, as he bears excruciating pains, with "apparent stoical insensibility;" and Humboldt speaks of his "resignation." So, too, of the Uaupes: Wallace comments on "the apathy of the Indian, who scarcely ever exhibits any feelings of regret on parting or of pleasure on his return." And, that a character of this kind was wide-spread, seems implied by testimonies respecting the ancient semi-civilized peoples of America, who were not impulsive. Nevertheless, there are among these races traits of a contrary kind, more congruous with those of the uncivilized races generally. Spite of their usually unimpassioned behavior, the Dakotas rise into frightful states of bloody fury when killing buffaloes; and among the phlegmatic Creeks there are "very frequent suicides caused by trifling disappointments." Some of these American indigenes, too, do not show this apathy: as, in the North, the Snake Indian, who is said to be "a mere child, irritated by, and pleased with, a trifle;" and as, in the South, the Tupis, of whom it is said that "if a savage struck a foot against a stone, he raged over it, and bit it like a dog." This exceptional non-impulsiveness in many American races may possibly be due to constitutional inertness. Among ourselves, there are people whose habitual equanimity results from want of vitality: being but half-alive, the emotions produced in them by irritations have less than the usual intensities. That a general apathy, thus caused, may account for this peculiarity, seems in South America implied by the alleged sexual coldness.

Recognizing such anomaly as there may be in these facts, we find throughout the rest of the world a general congruity. Passing from North America to Asia, we come to the Kamtchadales, of whom we read that they are "excitable, not to say (for men) hysterical. A light matter set them mad, or made them commit suicide;" and we come to the Kirghiz, who are said to be "fickle and uncertain." Turning to Southern Asiatics, we find Burton asserting of the Bedouin that he is "a mixture of worldly cunning and great simplicity," and that his valor is "fitful and uncertain." And while, of the Arabs, Denham remarks that "their common conversational intercourse appears to be a continual strife and quarrel," Palgrave says they will "chaffer half a day about a penny, while they will throw away the worth of pounds on the first asker." Among the African races we find like traits. Captain Burton, saying that the East-African is, "like all other barbarians, a strange mixture of good and evil," describes him thus:

"He is at once very good-tempered and hard-hearted, combative and cautious; kind at one moment, cruel, pitiless, and violent, at another; sociable and

unaffectionate; superstitious and grossly irreverent; brave and cowardly, servile and oppressive; obstinate, yet fickle and fond of changes; with points of honor, but without a trace of honesty in word or deed; a lover of life, though addicted to suicide; covetous and parsimonious, yet thoughtless and improvident."

With the exception of the Bechuanas, of whom even temper and self-command are asserted, the like is true of the races farther south. Thus, in the Damara, Galton says the feeling of revenge is very transient—"gives way to admiration of the oppressor." Burchell describes the Hottentots as passing from extreme laziness to extreme eagerness for action. And the emotional nature of the Bushmen is summed up by Arbrousset as quick, generous, headstrong, vindictive —very noisy quarrels are of daily occurrence: "Father and son will attempt to kill each other." Among the scattered societies of the Eastern Archipelago, those formed of Malays, or in which the Malay blood predominates, do not exhibit this trait. The Malagasy are said to have "passions never violently excited"—are not quick in resenting injuries, but cherish the desire for revenge; and the pure Malay is described as not demonstrative. The rest, however, have the ordinary trait. Among the Negrittos, the Papuan is "impetuous, excitable, noisy;" the Feejeeans have "emotions easily roused but transient," and "are extremely changeable in their disposition;" the Andamanese "are all frightfully passionate and revengeful;" and we are told of the Tasmanians that, "like all savages, they quickly change from smiles to tears." Among other of the lowest races there are the Fuegians, who "have hasty tempers," and "are loud and furious talkers;" and the Australians, whose impulsiveness Stuart implies by saying that the "angry Australian *jin* exceeds the European scold," and that a man "remarkable for haughtiness and reserve sobbed long when his nephew was taken from him." Bearing in mind that such non-impulsiveness as is shown by the Malays occurs in a race that has reached a considerable degree of civilization, and that the lowest races, as the Andamanese, Tasmanians, Fuegians, Australians, betray impulsiveness in a very decided manner, we may safely assert it to be a trait of primitive man, possessed, probably, in a greater degree than is implied by the above quotations. What the earliest character was, we may best conceive by reading the following vivid description of a Bushman. Asserting his simian appearance, Lichtenstein continues:

"What gives the more verity to such a comparison was the vivacity of his eyes, and the flexibility of his eyebrows, which he worked up and down with every change of countenance. Even his nostrils and the corners of his mouth, nay, his very ears, moved involuntarily, expressing his hasty transitions from eager desire to watchful distrust. . . . When a piece of meat was given him, and half rising he stretched out a distrustful arm to take it, he snatched it hastily, and stuck it immediately into the fire, peering around with his little

keen eyes, as if fearing that some one should take it away again: all this was done with such looks and gestures, that any one must have been ready to swear he had taken the example of them entirely from an ape."

Indirect evidence that early human nature differed from later human nature, by having this extreme emotional variability, is yielded us by the contrast between the child and the adult among ourselves. For, on the hypothesis of evolution, the civilized man, passing through phases representing phases passed through by the race, will, early in life, betray this impulsiveness which the early race had. The saying that the savage has the mind of a child with the passions of a man—or, as it would be more correctly put, has adult passions which act in a childish manner—thus possesses a deeper meaning than appears. There is a genetic relationship between the two natures, such that, allowing for differences of kind and degree in the emotions, we may regard the coördination of them in the child as fairly representing the coördination in the primitive man.

The more special emotional traits are in large part dependent on, and further illustrative of, this fundamental trait. This relative impulsiveness—this smaller departure from primitive reflex action, this lack of the re-representative emotions which hold the simpler ones in check—is accompanied by improvidence.

The Australians are described as "incapable of any thing like persevering labor the reward of which is in futurity." According to Kolben, the Hottentots are "the laziest people under the sun;" and we are told that with the Bushmen it is "always either a feast or a famine." Passing to the indigenes of India, it is said of the Todas that they are "indolent and slothful;" of the Bhils, that they have "a contempt and dislike to labor"—will half-starve rather than work; while of the Santals we read that they have not "the unconquerable laziness of the very old Hill-tribes." So, from Northern Asia, the Kirghiz may be taken as exemplifying idleness; and in America we have the fact that none of the aboriginal peoples, if uncoerced, show capacity for industry. In the North, cut off from his hunting-life, the Indian, capable of no other, decays and disappears; and in the South the tribes disciplined by the Jesuits lapsed into their original state, or a worse, when the stimuli and restraints ceased. All which facts are in part ascribable to inadequate consciousness of the future—feeble grasp of distant results. Where, as among the Sandwich-Islanders, and in some of the Malay societies, we find considerable industry, it goes along with such a social state as implies discipline throughout a long past—conditions have caused considerable divergence from the primitive nature. It is true that perseverance with a view to remote benefit occurs among savages. They bestow much time and pains on their weapons: six months to make as many arrows, immense patience in drilling holes through stones. But in these cases, beyond the fact that the benefits are simple, proximate, and conspicu-

ous, it is to be observed that little muscular effort is required, and the activity is thrown on perceptive faculties which are constitutionally active.[1]

A trait which naturally goes along with inability so to conceive the future as to be influenced by the conception is a childish mirthfulness—merriment not sobered by thought of what is coming. Though sundry races of the New World, along with their general impassiveness, are little inclined to gayety, and though among the Malay races and the Dyaks gravity is a characteristic, yet generally it is otherwise. Of the New-Caledonians, Feejeeans, Tahitians, New-Zealanders, we read that they are always laughing and joking. Throughout Africa, too, the negro shows us everywhere this same trait; and of other races, in other lands, the various descriptions of various travelers are: "full of fun and merriment," "full of life and spirits," "merry and talkative," "skylarking in all ways," "boisterous gayety," "laughing immoderately at trifles." Even the Esquimaux, notwithstanding all their privations, are described as "a happy people." We have but to remember how greatly habitual anxiety about coming events moderates the flow of spirits—we have but to contrast the lively but improvident Irishman with the grave but provident Scot—to see that there is a relation between these traits in the uncivilized man. The relatively-impulsive nature, implying total absorption in a present pleasure, causes at the same time these excesses of gayety and this inattention to threatened evils.

Along with the trait of improvidence there goes, both as cause and consequence, an undeveloped proprietary sentiment. When thinking about the nature of the savage, we overlook the fact that he lacks the extended consciousness of individual possession, and that under his conditions it is impossible for him to have it. Established, as the sentiment can be, only by multitudinous experiences of the gratifications which possession brings, continued through successive generations, it cannot arise where the circumstances do not permit these experiences. Beyond the few rude appliances ministering to his bodily wants, the primitive man has nothing that he can accumulate—there is no sphere for an acquisitive tendency. Where he has grown into a pastoral life, there arises a possibility of benefits from increased possessions—he profits by multiplying his flocks. Still, while he remains nomadic, it is difficult to supply his flocks with unfailing food when they are large,

[1] It should be remarked as a qualifying fact, which has its physiological as well as its sociological interest, that the characters of men and women are in sundry cases described as unlike in power of application. Among the Bhils, while the men hate labor, many of the women are said to be industrious. Among the Kookies, too, the women are "quite as industrious and indefatigable as the Naga women:" the men of both tribes being lazy. Similarly in Africa. In Loango, though the men are inert, the women "give themselves up to" husbandry "with indefatigable ardor;" and our recent experiences on the Gold-Coast show that a like contrast holds there. The establishment of this difference seems to imply the limitation of heredity by sex.

and he has increased losses from enemies and wild animals; so that the benefits of accumulation are kept within narrow limits. Only as the agricultural state is reached, and only as the tenure of land passes from the tribal form, through the family form, to the individual form, is there a widening of the sphere for the proprietary sentiment.

So that the primitive man, distinguished by his improvidence, distinguished also by deficiency of that desire to own which checks improvidence, is, by his circumstances, debarred from the experiences which develop this desire and diminish the improvidence.

Let us turn now to those emotional traits which directly affect the formation of social groups. Varieties of mankind, as we now find them, are social in different degrees; and, further, they are distinguished by different degrees of independence—are here tolerant of restraint and here intolerant of it. Clearly, the proportions between these two characteristics must greatly affect the social union.

Describing the Mantras, indigenes of the Malay Peninsula, Père Bourien says: "Liberty seems to be to them a necessity of their very existence;" "every individual lives as if there were no other person in the world but himself;" they separate if they dispute. So, too, of the wild men in the interior of Borneo, "who do not associate with each other;" and whose children, when "old enough to shift for themselves, usually separate, neither one afterward thinking of the other." A nature of this kind manifestly precludes social development; and it shows its effects in the solitary families of the wood-Veddahs, or those of the Bushmen, whom Arbrousset describes as "independent and poor beyond measure, as if they had sworn to remain always free and without possessions." Of sundry races that remain in a low state, this trait is remarked; as in South America, among the Araucanians, "the Mapuché is impatient of contradiction, and brooks no command;" as, according to Bates, among the Indians of Brazil, who, tractable when quite young, begin to display "impatience of all restraint at puberty;" as among the Caribs, who were "impatient under the least infringement" of their independence. Sundry of the Hill-tribes of India, too, exhibit a kindred nature. The savage Bhils have "a natural spirit of independence;" the Bodo and Dhimal "resist injunctions injudiciously urged, with dogged obstinacy;" and the Lepchas "undergo great privations rather than submit to oppression." This impediment to social evolution we meet with again among some nomadic races. "A Bedouin," says Burckhardt, "will not submit to any command, but readily yields to persuasion;" and he is said by Palgrave to have "a high appreciation of national and personal liberty," and "a remarkable freedom from any thing like caste feeling in what concerns ruling families and dynasties." That this moral trait is injurious during early stages of social progress, is in some cases observed by travelers, as by Earl, who says of the New Guinea people that their "impatience of control" precludes organization. Not, indeed, that

absence of independence will of itself cause an opposite result. The Kamtchadales, according to Grieve, exhibit "slavishness to people who use them hard," and "contempt of those who treat them with gentleness;" and Galton, describing the Damaras as having "no independence," says they "court slavery"—that "admiration and fear" are their only strong sentiments. A certain proportion between the feelings prompting obedience and prompting resistance seems required. The Malays, who have evolved into several semi-civilized societies, are said to be submissive to authority; and yet each is "sensitive to any interference with the personal liberty of himself or another." Clearly, however, be the cause of submission what it may—whether want of self-assertion, or fear, or awe of superiority, which, separately and together, in different proportions, favor subordination—a relatively-subordinate nature is everywhere shown by men composing social aggregates of considerable size. In such semi-civilized societies as tropical Africa contains, it is conspicuous; and it was manifest in the peoples who formed the extinct Oriental societies, as also in those who formed the extinct societies of the New World.

If, as among the Mantras above named, intolerance of restraint is joined with want of sociality, there is a double obstacle to social union: a cause of dispersion is not checked by a cause of aggregation. If, as among the Todas, a man will sit inactive for hours, "seeking no companionship," he is under less temptation to tolerate restrictions, han if solitude is unbearable. Clearly, the ferocious Feejeean, in whom, strange as it seems, "the sentiment of friendship is strongly developed," is impelled by this sentiment, as well as by his extreme loyalty, to continue in a society in which despotism based on cannibalism is absolutely without check.

When we average the evidence, first as presented by the very lowest men who group themselves socially to the smallest extent, and then as presented by more advanced men forming larger aggregates, we find warrant for saying that primitive men, who, before any arts of life were developed, necessarily lived on wild food, implying wide dispersion of small numbers, were, on the one hand, not much habituated to associated life, and were, on the other hand, habituated to that uncontrolled following of immediate desires which goes along with separateness. So that, while the attractive force was small, the repulsive force was great. Only as primitive men were impelled into greater gregariousness by local conditions which furthered the maintenance of many individuals in a small area, could there come that increase of sociality required to check unrestrained action. And here we see yet a further difficulty which stood in the way of social evolution at the outset.—*From the "Principles of Sociology," Part I.*

BIOLOGY FOR YOUNG BEGINNERS.[1]

By SARAH HACKETT STEVENSON.

UNDER the low eaves at the back of the house was a long, deep wooden trough for catching the rain that fell on the roof. This old trough was to me a never-failing source of wonder and delight during my childhood. The inside of it was all lined with a beautiful, green, velvety mould, and, when there had been no rain for some time, the water itself would turn a greenish color. We used to catch our little downy yellow ducks and put them in the trough to see them swim, and sometimes they would break off and eat the green mould with their curious shovel-bills. What this queer, green stuff was, and how it came there, was a great mystery to us children. Charley declared it came down in the rain just as the angle-worms that he used for fish-bait. I had to wait a long time to find some one to explain to me all about these simple things. No doubt I might have learned about them here at home, if I had tried hard enough; but it so happened that I found a great professor in London, who was teaching his students just what I wanted to know, and he explained so well what I had seen in the old water-trough, and many other curious things, that I have thought my young friends might like to hear about them also. I am sure I should have been very glad if I could have found any one to explain them to me when I was a child.

Probably you have no trough in which you can find this green mould, but there is plenty of it on old palings, stone-walls, and the trunks of trees. That which comes on the top of water, and makes it look green, is a little different from that which covers old wood and stones, and we shall speak of this difference by-and-by. In order to see what there is in this green, mouldy matter, and what it is made of, you must look at it through the microscope. The word *microscope* comes from two words which mean *little*, and *to view*, and so this instrument is used to magnify, or make larger, things which are too small to be seen with the naked eye. Under it the dust of the butterfly's wing looks as large as the feathers of a canary-bird. Each of you ought to have a microscope of your own to study the things we are going to talk about, or several of you might club together and buy one, and use it "turn about." I am sure you would never regret the investment.

If you carefully scrape off a little of this mould from the trees or fences and look at it through the microscope, you can see that it is made up of exceedingly small bladders or bags. You will find little sacs

[1] From "Boys and Girls in Biology," now in the press of D. Appleton & Co., by a pupil of Prof. Huxley. Written upon the basis of his lectures, and illustrated by Miss M. A. J. Macomish.

something like these in all the substances we are going to examine. They are called *cells*. Sometimes cells are quite colorless and clear or transparent, but here you see they are colored—some are green, some red, and others are red in the middle and green at the border. You will notice that this coloring is all inside the cell, and not in the wall or outside cover of the cell; and sometimes, though not often, you can see this coloring-matter is formed in little grains. Now I wish you to

FIG. 1.—MOULD-CELL.

FIG. 2.—GREEN MOULD-CELL.

FIG. 3.—MOULD-CELL WITH RED CENTRE.

FIG. 4.—RED CENTRE AND GREEN BORDER.

notice the size and shape of the cells. You will find that most of them are from $\frac{1}{3000}$ to $\frac{1}{2000}$ of an inch in size, and nearly all of them have a round shape. Let us see now how many different things we can find in these cells. First, there is the outside cover or sac; this sac seems to be filled with something that looks like jelly, or the white of an egg, and in this jelly you can see the green and the red colored grains, a little round, hard-looking body that looks like a kernel, and sometimes in the middle of the sac there is a thin, empty-looking space. We will begin at the outside and look at each of these things separately, and try to find out what they are. If you press some of the

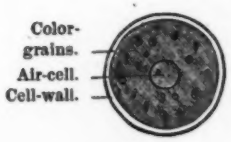


FIG. 5.

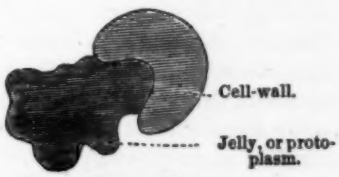


FIG. 6.—BROKEN CELL.

cells lightly they will burst, the soft inside part will flow out and leave the empty sac just the shape of the cell except where it is torn. This shows that the outside is much stronger and tougher than the inside. Chemists have found that this wall of the cell is made exactly the same as the tough cells of wood—it is called *cellulose*.

The light-colored jelly inside the sac has a long name of its own—*protoplasm*—which means *first form* or *mould*, because this seems to be the first form of all life. The green and the red colored grains are called *chlorophyll*. The word means *green leaf*. But *chlorophyll* is not always green: as you see in this mould, it is sometimes red, and it has many other colors; nor is it found in leaves only, as you will see when we come to study the stems and flowers of plants. But this dye-stuff or coloring-matter was first found in the leaves, hence its name—

green leaf. It is easy to remember; it will help you to think of the hard Greek name—*chlorophyll.*

The little round, hard kernel is called the *nucleus*, which means a nut or kernel, and the thin space in the centre is the *vacuole* or air-cell. It seems to be like a tiny drop of water separated from the rest of the jelly, which contains a good deal of water.

Now that we have described and named each of these different parts, we can go a step or even two steps farther, and tell of what the most of them are made, and of what use they are. The tough wall or sac of the cell is made of the woody matter or cellulose, mixed with a little water and mineral matter. The cellulose or woody part is made of three substances—*carbon*, *hydrogen*, and *oxygen*. If you ask me what these things are, I can only tell you that they belong to what are called the *simple chemical elements*, because each one is made of just one kind of matter. These three substances, and one other called *nitrogen*, help to make every thing there is in the world, except a few such things as gold, iron, sulphur, etc., which are also simple elements. The water is made of hydrogen and oxygen. Its use is probably to hold and protect all the inside parts, or contents of the cell. So much for the outside sac of the cell—now for the inside. The cell-jelly, or *protoplasm*, is made of water, fat, mineral matters, and *protein*. The water we already know. The fat is made of carbon, hydrogen, and oxygen. The minerals belong to the simple elements.

The *protein* we know but little about. We are sure that it contains carbon, hydrogen, oxygen, and nitrogen, with a little *sulphur* or *phosphorus*, or both, and we know that it is found in all living matter. There is no life without it, so it has been called the "basis of life." But there is a great deal more to be learned about it. I want you to remember what this word protein stands for, because it is something about this substance that makes one of the greatest differences between vegetables and animals. There is nothing in its appearance that would make you think it of so much importance; it looks to be nothing more than so much light-colored jelly, or white of egg. The word protein means *first* or *chief*, and this is the part of the protoplasm-jelly, which is alive. The kernel, or nucleus of the cell, seems to be only a part of the protein-jelly which is harder than the rest, and it has something to do with the making of new cells, as we shall see farther along in our study.

Now, what about the dye-stuff? Is it of any use, or is it just here to make the mould look pretty? It is of great use, as we shall soon see. Each grain is a very clever little chemist that works in the cell, which is his *laboratory*, or workshop. The sunlight is the fire by which this chemist heats his crucible, or melting-pot. Into this crucible he puts the poisonous gas, *carbonic acid*, that he gets from the air, and melts it up into *carbon* and *oxygen*, the two substances of which it is made. He keeps the carbon to feed upon, and gives back the pure

oxygen to the air again. Thus he works from sunrise to sunset. His hours are regulated by the sun, instead of by Congress. You never hear of an "eight-hour movement" or a "strike" among the chlorophyll laborers. As soon as the sun goes down they go to bed, like honest workmen. During the night, while these green-leaf or chlorophyll workers are asleep, the colorless protein-jelly of the cell gives out the poisonous carbonic acid and takes in oxygen. The green cells give off carbonic acid and take in oxygen during the day, as well as during the night, but the little chlorophyll-grains do so much more work than the rest of the jelly in the cell, it seems as though the cell gives out nothing but oxygen and takes in nothing but carbon during the day, when all these little colored chemists are doing their best.[1]

Now you can understand why it is healthy to have growing plants in your room during the day, but not during the night. When the sun is shining they purify the air, because they give off more oxygen than carbonic acid; but at night they poison the air, because they give off only carbonic acid.

All plants that contain this green-leaf matter, or chlorophyll, are called green plants. You remember the colorless plants, such as toadstools, are called *fungi*. It is found, as you have seen, that green plants must have the sunshine, but fungi grow as well, or even better, in the dark. Thus we have found the materials out of which the mould-cell is made, and the use of all its different parts. Who would have thought there was so much to learn in one of those little bladders, when you first looked at it under the microscope! This green mould-plant has a very pretty name of its own—*protococcus*. The word means *first berry*. Perhaps this name was given because these cells look like little berries.

FIG. 7.—"FISSION" OF THE CELL.

FIG. 8.—ONE CELL DIVIDED INTO FOUR.

If you look long and carefully, you can see the protococcus or berry-cell begin, like a little carpenter, to make a partition-wall right through the middle of the old house (Fig. 7); and, when the wall is finished, the two halves move away from each other, the carpenters

[1] Recent investigations seem to prove that the breathing of plants is similar to that of animals during both day and night; that the breaking up of carbonic acid is *digestion*, and not *respiration*. It has its seat in the chlorophyll, and is active in the sunlight; while the respiration, the breathing in of oxygen and the breathing out of carbonic acid, has its seat in the protoplasm, or protein of the cells. (*See* "Respiration of Plants," by Émile Alglave, POPULAR SCIENCE MONTHLY for November.)

round off the sides, and thus make two new houses out of the old one. Sometimes they build two partitions, as you see in Fig. 8, and, instead of two houses, there are four. What ingenious workers they are, thus to build four new houses out of one old one! They work so fast, too. The Chicago builders worked at the rate of a house an hour after the "great fire," but the protococcus builders can beat that, for they have been known to build one hundred thousand houses per minute, and that, too, in the winter-time, when the ground was all covered with snow!

The red protococcus, sometimes called "red snow," which is found in the arctic regions and among the Alps, will cover hundreds of acres of ground with its little red roofs in almost "less than no time." There are many curious stories told about this red snow. The ancients thought it was blood sprinkled down from heaven, as a warning of some great trouble, and it produced as much terror as comets and eclipses. But all the while it was only an innocent, pretty little plant. There is also a green protococcus that grows in the snow regions, and it is called the "green snow-plant." The red and the green snow-plants do not grow just in the same way as the protococcus of the trough or paling. The snow-carpenters divide their dwelling into a whole lot of little rooms (Fig. 9), then they "burst up" the old house entirely, and each one of the little rooms becomes a separate

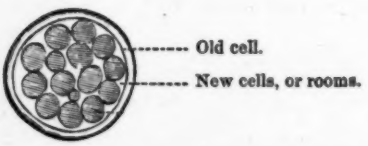


FIG. 9.—SNOW-CARPENTERS DIVIDING THE OLD HOUSE INTO NEW ROOMS BY CLEAVAGE.

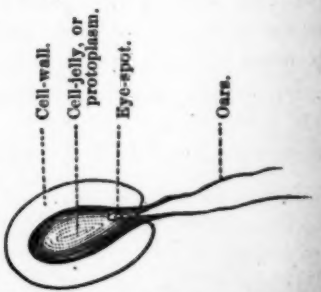


FIG. 10.—BOAT, OR PEAR-SHAPED CELL.

mansion, and goes on doing the same thing for itself. This mode of building is called "cleavage;" the first kind is called "fission."

I told you there was a difference between the mould on the sides and the mould in the water of the old trough. You see that the protococcus mould you are looking at does not move about under the microscope, but remains quietly where you place it. Now, if you examine some of the protococcus that grows in old water, you will see the cells sculling about very fast, like so many little boats. If your eyes and microscope are very good, you can see the two tiny oars by which the little boatman guides his craft. There seem to be two kinds of boats —one small, green, and pear-shaped (Fig. 10); the others are larger, and look more like the carpenters' houses. The little pear-shaped

boats often have a tiny red window, or port-hole, called the "eye-spot." If you watch long and carefully, you can see the little boatman pull in his oars (Fig. 12), as if to rest. But, if you shake the water, and then put it in the sun, out go the oars again, rowing faster than ever. The little pear-shaped cells do not have a tough, cellular sac; these independent little sailors seem to jump out of the boats

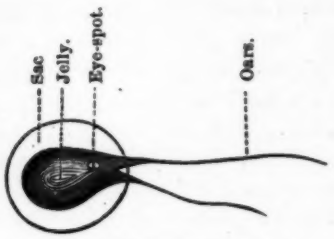


FIG. 11.—PROTOCOCCUS BOATS.

FIG. 12.—PROTOCOCCUS, OR BERRY-BOAT, WITH OARS PULLED IN.

entirely and swim about quite naked (Fig. 13). After they have bathed to their hearts' content, they seem to retire quietly to the sands and dress themselves again; that is, each one builds around himself a new wall, or boat, in which he rests till he needs another dip. The larger kind try to be more respectable; they stay in their boats in a dignified and proper manner. *Iodine* kills them, and then you can see where the little oars are pushed through the row-locks in the sides of the boat. These oars are called *cilia*—a word which

FIG. 13.—PEAR-SHAPED CELL WITHOUT A SAC, OR THE BOATMAN WITHOUT A BOAT.

means eyelashes. When the little sailors are getting tired, and just before they die, you can see these eyelash oars quite plainly, they move so slowly; but, when they are vigorous and the day is sunny, the oars move so fast you cannot see them. No Columbia or Cambridge crew can begin to pull with these protococcus boatmen. Besides being good oarsmen, they are also good builders. You may often see them breaking up the old boats by *cleavage* and *fission*, just as the carpenters break up the old houses.[1]

And so we have followed our quaint little friend, the protococcus, through all his occupations—chemist, carpenter, boatman, and shipbuilder. Now, I am sure you will never again pass by an old fence, or a pool of green water, without thinking of the wonderful little arti-

[1] The kind of berry-moulds that grow on old wood and stones, and in the snow, is called *still protococcus*; that which grows in old water, and moves about by oars, is called *moving protococcus*.

sans that are working there. When I watched the ducks swimming in the old trough, little did I think of the noiseless hands that were building up those velvety-green walls, or of the unseen and unnumbered fleet of boats sculling through the water.

Young folks have a great fancy for "bloody stories;" so I am going to tell you not exactly a "bloody story," but a story about blood, and you need not be alarmed, for before I finish you will find there is nothing in blood to alarm any one, but a great deal that is useful, curious, and beautiful. If you prick your finger with a needle, and squeeze out a drop of blood and place it under the microscope, you will be astonished at what you see (Fig. 14). You can hardly believe that a drop of blood contains so many curiosities. First you observe a whole lot of little reddish-looking bodies, and among these a number of larger transparent bodies, which look like minute splashes of light-colored jelly. It is about these jelly-like bodies I am going to talk with you. If

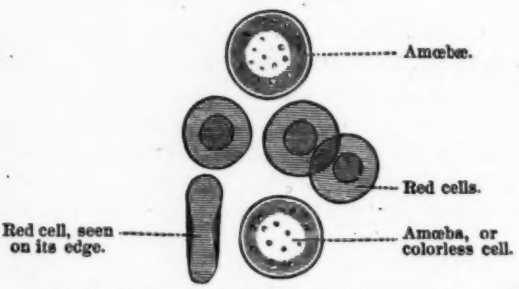


FIG. 14.—BLOOD-CELLS, COLORED AND COLORLESS.

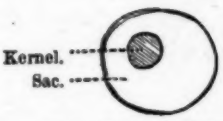
FIGS. 15 AND 16.—THE AMŒBA OR BLOOD-CELL CHANGING ITS FORM.

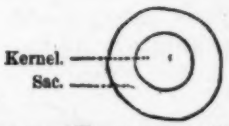
you keep your eye on one of them, you see that it continually changes its form, and that it has a slow, crawling kind of motion; and, if you try to make a drawing of it on paper, your picture will never be twice alike (Figs. 15, 16). It puts out something from one side which looks like a foot; then it draws in this foot, and puts out another at the other side, as if trying to find a soft place to walk upon. Sometimes it puts out several of these feet at one time. This little jelly-splash appears to use its feet as we use ours, to walk with, though you see it gets on quite slowly and awkwardly. Its foot is called a *pseudopodium*, which means *false foot*. These little bodies have a very suitable name—amœbæ, and the word means *changing*. This name was given to them, no doubt, because they are constantly changing their form. The amœba, or blood-cell, is larger than the still protococcus, or mould of the paling, and not quite as large as the moving protococcus, or green water-mould. It is usually about $\frac{1}{2500}$ of an inch in breadth. It does not possess the cellulose or woody sac, like the little protococcus houses. It is more like the pear-shaped protococcus boatmen. Its wall is just the hardened outer layer of the jelly or protoplasm. It has no thin

space or vacuole, no "eye-spot," no eyelashes or cilia, and when it is quite fresh and new you cannot see any kernel or nucleus. You really can see nothing but an odd-looking lump, with here and there some little grains inside of it. If you give it a drop of weak vinegar or *acetic acid*, the little grains will disappear, and you can see the kernel in the centre (Figs. 18, 19).

You can find this kernel much easier if you stain the cell with *magenta* or weak iodine. Heat makes these amœbæ or blood-cells move

FIG. 17.





FIGS. 18 AND 19.—CELLS CLEARED WITH VINEGAR, SO AS TO SHOW THE NUCLEUS.

much quicker, and it is very interesting to watch them make their way among the yellowish-red cells which lie in rows all around them. Sometimes one of the amœbæ will clear a channel for itself right through a thick group of the others. The first time I ever saw them moving in this way, I could not help thinking of the canals in Venice, where the gondoliers steer their gondolas close beside the houses, turning the corners so skillfully as never to strike them. So these little gondoliers of the blood went in and out, threading their way among the reddish-yellow cells, which stood in rows on either side the narrow channels (Fig. 20). There is one great difference, though: in Venice

FIG. 20.—THE AMŒBÆ PUSHING THEIR WAY AMONG THE RED CELLS.

the gondolier has nothing to do but follow the canals that are made for him, but the amœba gondolier has to make his way as he goes. No wonder you open your eyes! It is enough to open any one's eyes to think of the thousands of these odd creatures that go half creeping, half walking through one's veins. You know people sometimes talk about their "blood crawling," but very few people know *how* the blood crawls.

If you heat the amœbæ they pull in all their little feet and become perfectly white and still, and nothing you can do will ever bring

them back to life. These blood-cells that I have described are called "*human amœbæ*," or the amœbæ of man. Those that are found in the blood of other animals are somewhat different, but there is a kind of amœba, or crawling-cell, which grows on the top of stagnant water, that has a greater difference (Figs. 21, 22). Take a little of the scum that rises on ponds in hot weather, and put it under the microscope. In it you will find these jelly-lumps of a much larger size. They are from $\frac{1}{1000}$ to $\frac{1}{100}$ of an inch across, and move about by the same kind of queer-looking feet. But the border does not look at all the same. First, on the outside you see a clear, glassy-looking rim; inside of this is a thicker, darker ring filled with little grains—*granules*.

FIG. 21.—POND AMŒBA.

FIG. 22.—POND AMŒBA.

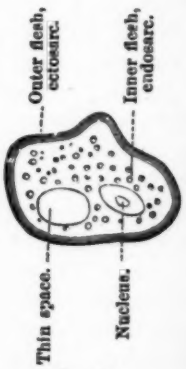


FIG. 23.

The centre of the cell is quite clear, and contains a thin space or vacuole, like that you saw in the yeast and green mould. The outer border or rim is called the *ectosarc*, which means outer flesh. The inner is called the *endosarc*, or inner flesh. Near the clear outer rim or ectosarc you will find the kernel or nucleus—a roundish, solid-looking little body which does not change its form. If you look closely you will see a small round, clear space in this outer rim or ectosarc which has motion, something like the beating of the heart. Indeed, by some it is thought to be the simplest form or beginning of a heart. It is called by a long name, the "*contractile vesicle*," or "*contractile space*." All amœbæ do not have this heart, nor do they all have a kernel. This contractile space or heart is very important, because it seems to be doing a work of its own. This is the first time we have found one part of a cell doing something entirely different from another part. The jelly or protoplasm of the yeast and the green mould is "maid-of-all-work." But the amœbæ family seem to be looking up in the world, and are trying to pattern after those establishments that keep a servant for each kind of work.

Inside of some of these large pond amœbæ you will often find the green protococcus-cells, little *diatoms*, *desmids*, and all kinds of cells

that are smaller than the amœba itself (Fig. 24). These it feeds upon, and, if you have patience to look long enough, you can see how it eats. It has no mouth in particular—the feet seem to taste of whatever comes in their way, and, if they like it, they grasp it, and poke it in anywhere into the middle of the jelly or protoplasm (Fig. 25).

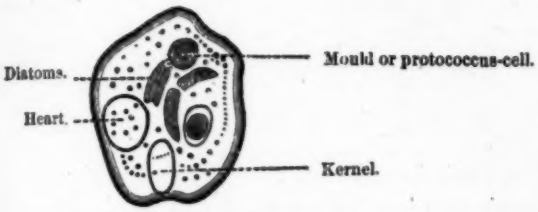


FIG. 24.—POND AMŒBA DIGESTING ITS FOOD.

FIG. 25.—AMŒBA EATING.

Here it is digested, and all parts that cannot be used are pushed out again. All that the amœba has to do is to swallow the mass, suck out all the meat, and throw the rest away. There is one thing you must remember about the amœba; it must have its food or protein ready made. It has no power like the yeast or protococcus cell to make it for itself. So these little jelly-lumps we find in the blood and the ponds must be animals. You remember, I told you all vegetables make protein, while all animals eat it up. This little amœba animal gets its full share. He is a perfect little gourmand, taking in every thing that comes in his way. The human amœbæ are more fastidious in their taste. They do not swallow their food whole like the wild amœbæ. But those that are found in the blood of the newt or frog are regular little cannibals, and eat up their "colored brethren" whenever they get the chance.

Then, too, the feet or pseudopodia of the savage tribe are thicker and shorter than feet of the civilized kind. You see the toes of your amœba are quite dainty and tapering, like a lady's fingers. It is very curious to watch how a pseudopodium is made, especially of the pond amœba. First there is a little swelling or lifting up of the glassy

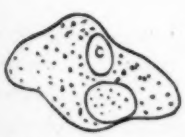


FIG. 26.—WILD AMŒBA.

FIG. 27.—HUMAN AMŒBA.

FIG. 28.—AMŒBA MAKING A FOOT.

rim or outer flesh (Fig. 28). As this swelling gets larger, some of the inner flesh flows into it, carrying the little grains, till the swelling is all filled up (Fig. 29).

Then the walking is so funny! The feet do not act as the feet of other animals, carrying the body above them. First, one stumpy foot

is put out as far as it can reach, then the body all runs into the foot, and another foot is stuck out from some other part, and away goes the body into this new foot. So it gets on, the feet actually swallowing

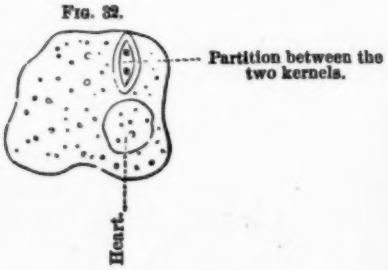
FIG. 29.—GRAINS FLOWING INTO FOOT.

FIG. 30.—TRYING TO WALK.

FIG. 31.—STAINED WITH MAGENTA.

the body! The toad sometimes swallows its old skin, but the amœba is the only animal I know which is "taken in" by its feet! How odd it would be, if, as you walk along, you should suddenly disappear into your boots! If you crush the amœba, you find no trace of a tough sac such as you found in the yeast and protococcus cells. You can see nothing but the kernel or nucleus, and even that soon disappears. If you stain with magenta or iodine, the whole cell becoms colored alike. If there were a tough, woody sac, as in the yeast and mould, it would not be stained. The iodine does not give it a blue color, so there cannot be any starch in the amœbæ. The amœbæ grow like the green-mould cells, by fission, that is, by one or two partitions made through the old cells. You will first see two kernels appear in one of the old cells; then, by close watching, you see a partition going right down between the kernels, separating the old cell into two, with a kernel or

FIG. 32.



nucleus in each. Each new cell follows in the footsteps of its ancestors, crawling, eating, and growing, in the same way. And now I hope you have learned enough about this curious *amœbæ* family to put your wits to work and give us, some day, a full history of them, and tell us of what use they are, and what they mean by all their motions.

Boys, and girls too, sometimes, love to wade in ditches and ponds in warm weather. When you are thus wading, some time, if you will take up a piece of the duck-weed that grows on the surface of the water, you may see a number of slender green, brown, or orange-col-

ored bodies, about a half-inch long, hanging down from the weed. If you shake or touch them the least bit, they get sulky and shrink

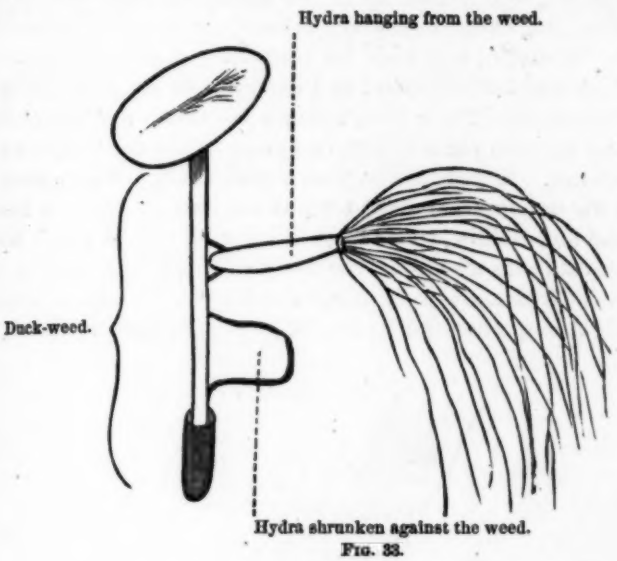


FIG. 33.

all up against the stem, looking like little pouting lumps of jelly. Place your bits of weed in a glass of water, and set the glass in the

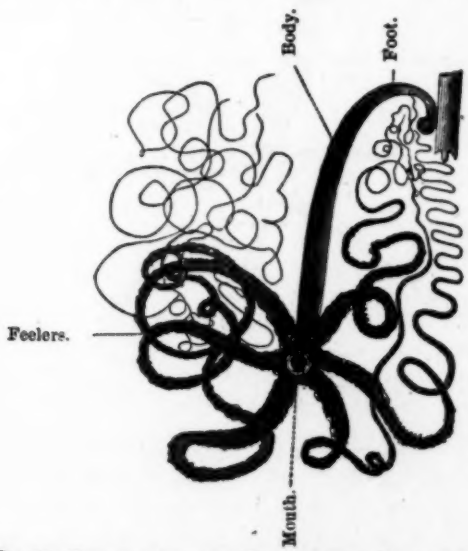


FIG. 34.—HYDRA FISHING FOR FOOD WITH ITS FEELERS OR TENTACLES.

light, but not in the sun, and in a few hours you will find a good many of these little creatures clinging to the side of the glass toward

the window. They hold on to the glass by one end, and all around the other end, which is wider, are a number of long threads called *tentacles*, hanging down gracefully in the water. At first you might think them whiskers, as they grow out around the mouth, but *tentacle* means a *feeler* or *holder*, and with its *tentacles* you will see how our little friend feels and holds its food, and carries it to his mouth, almost as you use you fingers. These little animals are called hydræ, because if you cut them up each piece will grow again, as did the heads of the old Greek monster. If you look at your hydra under the microscope, you will find all these parts: first, there is the part by which it holds on; it is round and hollow, something like the bottom of a fly's foot, and it changes its size whenever the body of the hydra changes its form. When the hydra is stretched out full length, the foot is smaller than the body; but, when the hydra shrinks up against the glass, it

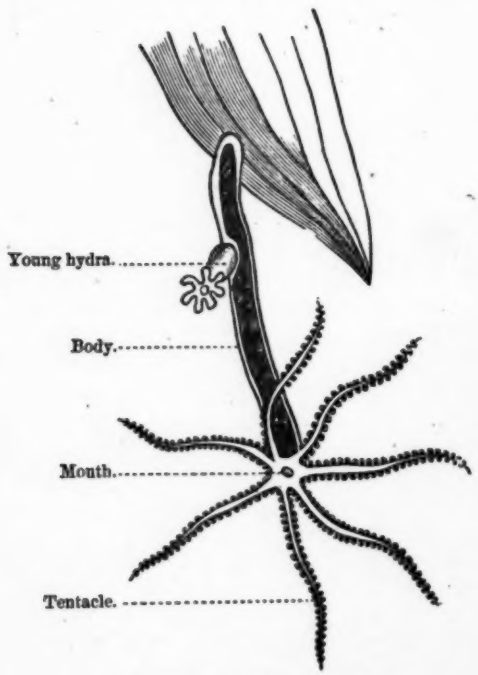


FIG. 35.—GREEN HYDRA.

seems to be all foot. When the body is stretched out, it is round and hollow like a pipe-stem, or more like a very slender funnel, and the opening at the large end surrounded by tentacles or feelers is the mouth.

The hydra's feelers are not all the same length; some of them are prettily colored, and all are filled with wavy knobs or knuckles along the sides (Fig. 35). The bag or body of the hydra is made of two

coats. The outer coat is the *ectoderm* or "outer skin," the other is the *endoderm* or "inner skin" (Fig. 36). The cells in the outer skin of the *green hydra* contain those green grains or chlorophyll which give the green color. It is curious to see that the hydra makes its fingers, or tentacles, somewhat as the amœba makes its feet, or pseudopodiæ (Fig. 36). It pushes out its two coats in the same way, but it never allows its fingers to swallow it as the amœba is swallowed by

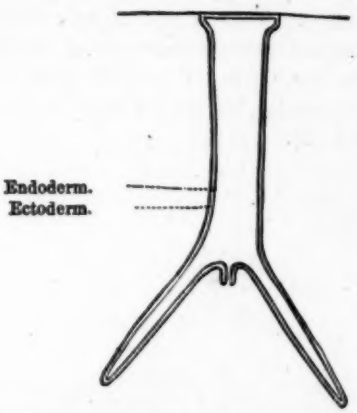


FIG. 36.—HYDRA PUSHING OUT ITS FINGERS.

its feet. When it is disturbed or frightened, it seems to swallow its fingers, or rather puts them all into its mouth, like a sulky child. It is a good deal higher up in the world than the amœba, for you remember that had to eat with its feet. Then, too, the hydra has a more aristocratic walk than the amœba. You can see it plant its foot firmly against the glass, then proudly bow its back and draw the rest of its body up to the foot, in the form of a loop, like the "looping caterpillar" (Fig. 37).

FIG. 37.—LOOPING CATERPILLAR.

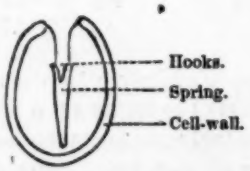


FIG. 38.—THREAD-CELL.

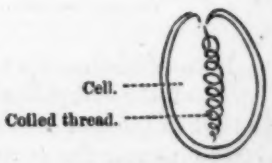


FIG. 39.—THREAD-CELL.

To be sure, it goes backward, but it is a great improvement on the walk of the amœba. It is also an excellent swimmer. You may often see it lift up its foot and dash into the water in search of food. It is one of the funniest things in the world to see the hydra catch its prey. I remember in my old geography a picture of Indians catching wild-horses with *lassos*. The lasso is a long rope with a loop at the end,

which the Indian skillfully throws over the horse's head as he chases it over the prairies. So the hydra throws out his long, rope-like fingers, and lassoes the little animals that swim near it. Sometimes it gets hold of animals so strong that they may tear the fingers or tentacles, and get away again. But the hydra will not be outdone in this way. He has another weapon at hand. Some of the cells in the outer skin are oval, or egg-shaped, and if you look through the cell-walls you see inside what appears to be a long, coiled thread, with two hooks at the bottom (Figs. 38 and 39). These egg-shaped cells are called "*thread-cells*," and the hydra has many thousands of them in his feelers or tentacles. This thread or spring darts out of its shell whenever the hydra needs it, and sticks itself into the body of the prey like a sharp harpoon (Figs. 40 and 41).

FIG. 40.—THREAD-CELL, WITH ITS THREAD UNCOILED.

FIG. 41.—THREAD-CELL, WITH THE SPRING TURNED OUT LIKE A HARPOON.

If you examine this harpoon closely, you will find that it is only a part of the cell poked in like the finger of a glove turned inward; and when the fingers, or *tentacles*, seize an animal, these glove-finger cells that cover the *tentacles* all dart out. Some of them seem to contain a poisonous juice which stupefies or kills the prey in an instant. There is an animal in the sea called the *Portuguese man-of-war*, which is really a dangerous creature, it has so many of these sharp harpoons. When the prey is stunned or dead, the fingers carry it to the mouth, and it passes down into the long tube or body of the hydra, where it is digested, as though it were in a regular stomach. Along the outside of this funnel-shaped body you may often see little buds, which grow and give off other buds, till the old hydra looks like

a branching tree. These buds, no doubt, make you think of something you have seen before—the yeast-babies—yes, these are the *baby-hydræ*. Soon their fingers begin to grow; then they loosen themselves from the old mother hydra, and begin to "fish for themselves." The next time you go wading, you must try and capture some of these

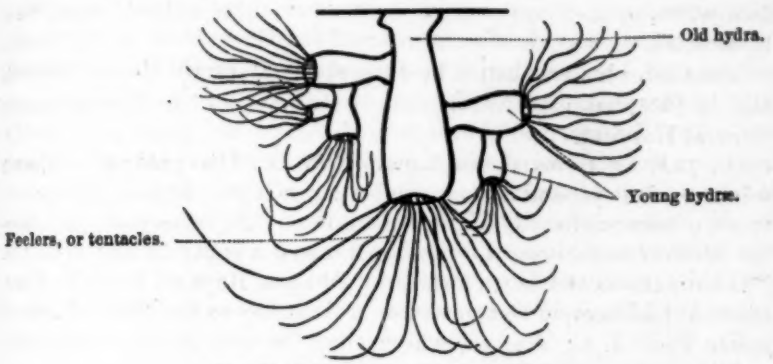


FIG. 42.—OLD HYDRA AND YOUNG ONES.

wonderful little creatures, and see if you can find all that I have described without my help. You are now, I trust, opening your eyes to the great world of living things all around you, in which you have lived and played, as I lived and played—*blindfolded*. And, when once your eyes are really open, wide, there is no telling what wonders they may behold.

SKETCH OF DR. JEFFRIES WYMAN.

BY BURT G. WILDER,
PROFESSOR OF ZOOLOGY IN CORNELL UNIVERSITY.

WITHIN a year, science has lost two of her greatest leaders, Louis Agassiz and Jeffries Wyman. With the life, the works, and the appearance of the one, all are familiar. But the other was hardly known outside of strictly scientific circles. He rarely gave popular lectures, and never wrote any thing that attracted general attention. Yet his influence upon the progress of science in this country has been very great, and he had for years been regarded by all as the highest anatomical authority in America, and the compeer of Owen, Huxley, and Gegenbauer, in the Old World.

JEFFRIES WYMAN was born at Chelmsford, near Lowell, Massachusetts, August 11, 1814. His father was a physician, as is his surviv-

ing brother. He was prepared for college at Phillips (Exeter) Academy, entered Harvard University in 1829, and was there graduated. During his last year in college he had an attack of pneumonia, which nearly proved fatal; this doubtless predisposed him to the pulmonary weakness from which he suffered during the latter part of his life, and from which he died on the 4th of September, 1874, at Bethlehem, New Hampshire.

Soon after his graduation he entered the Harvard Medical School, and, in 1836, became "house medical student" in the Massachusetts General Hospital.

In 1837 he received the degree of M. D. His graduation thesis was upon the eye, and accompanied by drawings. It does not appear to have been published, but, in September of the same year, the *Boston Medical and Surgical Journal* contained a paper by him upon the "Indistinctness of Images formed by Oblique Rays of Light." Soon afterward he became Demonstrator of Anatomy in the Medical School under Prof. J. C. Warren, whose chair he was destined afterward to fill.

In 1839 he accepted the curatorship of the newly-founded Lowell Institute. Two years later he delivered therein his first course of public lectures (of which no report has come under our notice), and with the money so earned went abroad for a year to pursue his medical and scientific studies under the great European masters. He had already, since 1838, published, in the *American Journal of Science*, several brief papers upon anatomical and physiological matters.

In 1843 there were published, in the *Journal of the Boston Society of Natural History*, anatomical descriptions of two gasteropod mollusks (*Tebennophorus Carolinensis* and *Glandina truncata*). Likewise a paper on the chimpanzee (*Troglodytes niger*), in which, with characteristic modesty, his account of its organization (though subversive of some of Owen's previous conclusions) is subordinated to Dr. Savage's remarks upon its habits and external characters. The same year he was appointed Professor of Anatomy in the Hampton-Sidney Medical College, at Richmond, Virginia. During his four years' stay his contributions to science included some notes upon fossil remains of vertebrates, and longer papers upon the blind fish of the Mammoth Cave and the teeth of the gar-pike (*Lepidosteus*). The latter paper is illustrated by microscopic sections, showing the close resemblance of the gar-pike's teeth to those of the fossil batrachian *Labyrinthodon*. The article closes with the suggestion that some of the separate teeth then referred by Owen to the latter genus might really belong to Lepidostean forms. This paper alone, though little known and never quoted by its author, would serve to show what manner of man was rising in America.

In 1847, at the age of thirty-three, he was chosen to the Hersey Professorship of Anatomy, at Cambridge. The year of his inaugura-

tion was signalized by his account of the gorilla, based upon specimens forwarded to him by Dr. Savage. This was the first scientific description of the new *Troglodytes*.

From that time forward his scientific progress was rapid and unbroken. He collected, he investigated, he lectured, he wrote. His admirable course of lectures upon Comparative Physiology, before the Lowell Institute, in 1849 (the report of which in pamphlet form has long been out of print), soon caused him to be regarded as the foremost among American anatomists and physiologists.

During this period, and indeed until within a few years of his death, Prof. Wyman published frequent brief notices of new animals, of points of structure and function, the value of which is in no way to be measured by their length. Almost any one of them would have served a less modest man for an extended memoir, while several contain the elements of interesting popular articles. So far from this, Prof. Wyman seemed to attach little personal importance to them, rarely referred to them, or took any pains to have them reproduced elsewhere. Many were, however, copied into European journals.

His first extended paper was "On the Nervous System of *Rana pipiens*" (the bull-frog). It covers fifty quarto pages, with two plates, was published by the Smithsonian Institution in 1853, and should be in the hands of every student of either human or comparative anatomy, as the clearest introduction to the most complex of animal structures.

Somewhat similar to the last, not quite so long, but even more replete with fact and philosophy, is the "Observations on the Development of *Raia batis*" (a skate), published by the American Academy of Arts and Sciences in 1864. This was based upon few materials, but sufficed to convince him, and all naturalists, that the skate ranks higher than the shark, since the latter retains through life a general form resembling one of the stages through which the former passes during its development.

Those who knew Wyman's nature may well imagine how he shrank from any thing like a discussion of two great questions upon which so much has been written during the past fifteen years, namely, the "Origin of Species" and "Spontaneous Generation." But, aside from his natural desire to know and teach the most correct doctrine upon these subjects, his prominent position made it imperative that he should consider them carefully. Respecting evolution, he evidently felt, with Prof. Gray, that, "upon very many questions, a truly wise man remains long in a state of neither belief nor unbelief; but your intellectually short-sighted people are apt to be preternaturally clear-sighted, and to find their way very quickly to one or the other side of every mooted question." In 1863 he wrote as follows: "We must either assume, on the one hand, that living organisms commenced their existence fully formed, and by processes not in accordance with

the usual order of Nature, as it is revealed to human minds, or, on the other hand, that each species became such by progressive development or transmutation; that, as in the individual, so in the aggregate of races, the simple forms were not only the precursors, but the progenitors of the complex ones, and that thus the order of Nature, as commonly manifest in her works, was maintained."

No one can help seeing that he inclined toward belief in the general doctrine, but he neither indorses "Darwinism" nor denounces those who find themselves unable to accept "derivation" in any sense.

Regarding the appearance of organisms *de novo*, he never allowed himself to express a final opinion. He published two papers embodying the results of numerous and accurate experiments, and, we have reason to know, was still continuing his observations at the time of his death.

The general question to which Prof. Wyman gave most attention, until called from it by the Archæological Museum, was that of Organic Symmetry, especially as manifested in the limbs. Accepting the usual belief in an homology of the front and hind limbs, he associated therewith the idea first put forth by Oken, that the two ends of the body are symmetrical, or reversed repetitions of each other, as are the right and left sides. The application of this doctrine to the limbs makes the ulna the homologue of the tibia, the radius of the fibula, and the thumb of the *little-toe*, instead of the great-toe, as ordinarily believed.

So radically does this interpretation of "intermembral homologies" differ from that of most anatomists, that it is not strange that its acceptance is, at present, confined to a very few (Foltz, in France, and, in this country, Dana, Coues, Folsom, and the writer). But we are encouraged by the reflection that our leader never gave even a qualified assent to any doctrine which did not prove to be in the main correct.

Upon no other single problem did he bestow so much thought. And, as may be inferred, it is in his treatment of this question that his peculiar characteristics appear. In the adoption of new ideas he manifested a wise caution, which, contrasted with the haste of others less well informed, illustrates the maxim, "Fools rush in where angels fear to tread." We recall his freedom in discussion with his students and his kindness in aiding their advancement, even to his own apparent detriment; his modesty, occasioning a lack of reference to his own papers or to unpublished investigations; his critical acumen, which was the more searching and useful from its entire freedom from personality; and, finally, here shine forth in their greatest brilliancy those rare qualities which enabled him, when occasion required, to overlook the delusive charms of teleology, though upheld by popular interest and theological authority, and to regard her plainer but more

reliable sister, morphology, supported by relative position and mode of development.

In 1866 Prof. Wyman was named one of the seven trustees of the Peabody Museum of American Archæology and Ethnology, and became curator. For this work he was peculiarly fitted, both by nature and by his extensive observations upon crania, and his frequent investigations of shell-heaps, etc., during the trips to Florida, which his health had of late years forced him to make. Our space will not permit even a brief sketch of his labors in this new field; the results are modestly recorded in his annual reports. At present, the Museum is very extensive and admirably arranged. Had Prof. Wyman been spared for another ten years, one can hardly predict its importance. Of this, and of his own anatomical collections, the value is wholly out of proportion to the size or actual cost in money, for they represent the constant and skillful labor of a great anatomist during a quarter of a century. The label upon every specimen tells the truth so far as he knew it; and in the descriptive catalogues are rich treasures of fact and thought as yet unrevealed.

Prof. Wyman always shrank from public notice, and from positions in which this was involved. He attended several meetings of the American Association for the Advancement of Science, and served therein as president, treasurer, and secretary. But his communications were few, and comparatively unimportant. He was a member of the American Academy of Arts and Sciences, and was named by Congress one of the original fifty members of the National Academy of Science, but soon resigned. In strong contrast with his slender relations with these organizations is his record in connection with the Boston Society of Natural History. He early became an ardent member, served as secretary, and as curator of several departments, and in 1856 became president. This office he held until 1870, when he offered an unqualified resignation.

Meagre as is the above account of his outer life, we shrink yet more from any such estimate of his abilities and his personal character as the present occasion will permit. Admired and trusted by his associates, by the younger naturalists he was absolutely adored. Ever ready with information, with counsel and encouragement, so far from assuming toward them the attitude of a superior, he on several occasions permitted his original observations to be more or less merged within their productions. The universal regard in which he was held by them is, in the writer's case, intensified by the sense of peculiar obligations, which might cloud his judgment of any ordinary man; but to no man more fitly than to Wyman could be addressed the lines:

> "None knew thee but to love thee,
> Nor named thee but to praise."

Nor was any criticism ever made upon him, from any quarter, other than upon his extraordinary freedom from personal ambition, and his aversion to public notice or display.

Wyman's anatomical work was absolutely free from zoological bias, and his statements were always received as gospel by both parties to a controversy. He might not tell the whole truth, for he might not see it at the time; but what he did tell was "nothing but the truth" so far as it went. The hottest partisan felt that a figure or description of Wyman's was, so far as it went, as trustworthy as Nature herself.

Without brilliancy, Dr. Wyman combined qualities rarely found in the same individual. No man of our time has surpassed him in the love of Nature for its own sake, free from the hope of position, power, or profit; in keenness of vision, both physical and mental; in absolute integrity, with the least as well as the greatest things; in industry and perseverance; and in method, whether for the arrangement of collections, or the presentation of an idea. And if to these had been adjoined a tithe of the ambition displayed by smaller men, and had his health and strength been at all equal to his mental powers, no one can doubt that his attainments, his productions, and his reputation, would have been surpassed by none of his contemporaries.

However much we may, for our own sakes, regret that such was not the case, we know that into his mind never entered the shadow of bitterness. His recognition of others' labors was full and generous; his mind was upon the facts and principles of Nature, and regarded not the medium through which they were obtained; and if he ever prayed for health and strength, it was surely not for his own advancement, but because he felt within himself the desire and the ability to learn and to teach the truth.

Dr. Wyman's reputation was less wide than that of some others; but it was deeply rooted. As the years roll on, and as the final estimate is made of the value of what has been done in this century, we may be sure that the name of Jeffries Wyman will stand high among those who have joined rare ability and unwearied industry with a pure and noble life. To use his own words upon a like occasion, "Let us cherish his memory and profit by his example."

EDITOR'S TABLE.

THE CONFLICT OF RELIGION AND SCIENCE.

IT is a common remark that there is no necessary hostility between religion and science; and this is unquestionably true. That they will be ultimately harmonized we cannot doubt; but the world is very far from having yet reached that blessed consummation. The scientist and the religionist can get on comfortably together as long as they talk in very general terms; but when they come to close quarters, and press earnestly for definitions, collision is pretty certain to ensue. This is partly due to the one-sidedness of the parties; much to still unresolved difficulties in the relation of the subjects; and not a little, it must be confessed, to that spirit of pugnacity by which humanity is still eminently animated. It is an age of propagandism and proselyting by tongue and pen; and the graceless multitude, moreover, always enjoys a good fight. The Archbishop of York was called to Edinburgh to lecture before the Philosophical Society, and the chance of pommeling some of our modern so-called philosophers was too good to be lost. Prof. Huxley happened to be engaged to give a lecture in the same town shortly after, invited by a religious body, and he would have been more a saint than his predecessor, if he could have refrained from giving back some of the archbishop's blows. In vindicating his school from the charge of materialism, Prof. Huxley felt it incumbent upon him to inquire into the nature of the juices of living things, and thus innocently kindled the great war of protoplasm that has stirred the combative propensities of the religious and scientific world to this day. And again, from the way the President of the British Association has been lately belabored by religious and semi-religious people of all sorts, we must conclude that the temper of antagonism is far from having yet died out, and that there must be a good deal more vigorous campaigning before a peace will be finally conquered.

Indeed, this conflict just now threatens to assume far larger proportions, and to be renewed upon a scale which we have been accustomed to consider as belonging to the distant past. The entire population of Europe is estimated at about 301,000,000, of which 185,000,000 are Roman Catholics, 71,000,000, Protestants, broken up into numerous sects, and the remainder are Greek Catholics, Jews, and Mohammedans. The adherents of the Roman Catholic Church are thus more numerous, by 69,000,000, than all sorts of religious people taken together. The Roman Church is the most extensive and powerfully organized of all modern societies, and with a mighty prestige of historic associations and traditions, claims to be supreme, infallible, to act under a divine commission, to have for its head the vicegerent of God, and to exact the most implicit obedience from all the members of its communion. It had long been believed that the Roman Church, silently yielding to the advance of intelligence and the growing spirit of liberality in modern times, has abated something of its ancient and arrogant pretensions; but there is not a little reason to think that this was an erroneous impression. In his "Encyclical Letter," put forth by the head of the Church, in 1864, the pope denounces that "most pernicious and insane opinion, that liberty of conscience and of worship is the right of every man, and that this right ought, in every well-governed state, to be proclaimed and asserted by law; and that the will of the people, manifested by public opin-

ion (as it is called), or by other means, constitutes a supreme law, independent of all divine and human rights." It denounces "the impudence" of those who presume to subordinate the authority of the Apostolic See "conferred upon it by Christ our Lord, to the judgment of the civil authority." In 1868, Pius IX. issued a bull convoking an Œcumenical Council to meet at Rome, December 8, 1869, and its sessions lasted till July, 1870. The decrees of the Vatican Council, carried by 451 out of 601 votes, asserted the infallibility of the Roman pontiff, and defined the relations of religion to science. Many opinions were solemnly condemned, and their holders anathematized. Among others:

"Let him be anathema—

"Who shall say that human sciences ought to be pursued in such a spirit of freedom that one may be allowed to hold as true their assertions, even when opposed to revealed doctrine.

"Who shall say that it may at any time come to pass, in the progress of science, that the doctrines set forth by the Church must be taken in another sense than that in which the Church has ever received and yet receives them."

The gauntlet was thus thrown down by this august and powerful religious body to science, independent inquiry, and the whole spirit of modern civilization. The old conflict was revived with no narrowing of the issues. The Archbishop of Westminster, Dr. Manning, in his late inaugural address to the Roman Catholic Academia, referred to "the modern skepticism, free thought, and so-called scientific teachings of the day in relation to Catholic teaching; and, for an illustration of the style of thought, he would refer them to Prof. Tyndall's address the other day at the Belfast meeting of the British Association." He furthermore said: "Within the last twenty-four hours it had been intimated to him that the Catholic world was threatened with a controversy on the whole of the decrees of the Vatican Council. From this and other matters which had come to his knowledge, he could see that they were on the very eve of one of the mightiest controversies the religious world had ever seen. Certainly nothing like the controversy on which they were about to enter had occurred during the last three hundred years, and they must be prepared. If they would only prepare themselves, he did not fear for the decrees of the Vatican Council, or for the Vatican itself. But they must have no half-hearted measures." The expected stroke came in the shape of an able pamphlet from Mr. Gladstone, in which he asked of English Catholics what they are going to do about the demands of the Vatican Council in regard to their allegiance to the pope in matters of civil authority. The document of the English statesman has been extensively diffused, has made a profound sensation, and precipitated vehement discussion in all quarters.

But Mr. Gladstone has only touched the surface of the subject. He takes a politician's view of the influence and tactics of the Church; yet this is by no means its most important aspect. With the decline of the temporal power of Rome, spiritual control is substituted for secular control, and the pressure taken off of the state is put upon the individual. While Mr. Gladstone's imputation that Catholics are lacking in loyal allegiance to government is resented by the representatives of the Church with indignation, no question is raised as to the invincible purpose of the Roman power to resist the advance of free thought and the progress of liberal opinions. And this is immeasurably the most important aspect of the subject. The right of the pope to sit in judgment upon the civil power may be still asserted for consistency's sake; but, his right to coerce the individual conscience, to repress free investigation, to decide what

is true and what is false, on the most momentous questions, and to take absolute control of the work of education, is maintained with earnest purpose and unabated rigor. It was to this task that the Vatican Council mainly addressed itself. The increasing spread of science was the ground of alarm, and against it the anathemas of the Council were chiefly hurled. With these relations of the subject Mr. Gladstone has not dealt, while, to deal with them broadly and thoroughly, requires a mind with a very different preparation from his.

The question is, first of all, an historic one. As the future must be determined by the tendencies of the present, and as these tendencies are the outcome of the past, he who would broadly comprehend the issues of today must turn back and study the contests and struggles of former generations through which the present state of things has been reached. The Catholic prelate of England says that we are on the "eve of one of the mightiest controversies the religious world has ever seen," but this cannot be an uncaused result; it is rather the natural and necessary sequence of "one of the mightiest controversies" which has been agitating the world for thousands of years. It is a controversy in which the elements of obstruction and of advancement have been in play upon an immense scale, which has drawn nations into its vortex, and issued in nothing less than the development of civilization itself. Nothing has been more wanted than a delineation of the causes, the course, and the consequences of this great struggle; and this desideratum is now supplied by the "History of the Conflict between Religion and Science," by Dr. John W. Draper.

The author of this work has won a world-wide reputation alike as a man of science and an historian, both qualities being required in an eminent degree for the performance of the task. Dr. Draper began his scientific studies in extreme youth, and they have taken a wide range. Both in the field of physics and in that of physiology he is a master, and his eminent position as an original investigator has been long conceded in all civilized countries. He has done his share in extending the boundaries of knowledge, and his acquaintance with science is therefore not at second-hand, but is thorough and trustworthy. Being of a philosophic cast of mind, he was early drawn to the consideration of science in its historic development. He thus passed to the study of history, and naturally took up its problems from the scientific point of view; that is, he read them in the light of an extensive familiarity with the laws of the natural world. His "History of the Intellectual Development of Europe" is a work of great learning and originality, which has been translated and republished in all the leading civilized countries of the world. That it has been highly appreciated by eminent men, need hardly be said. It was quoted, as we are all aware, by Prof. Tyndall, in his late address before the British *savants;* and when not long ago, in Berlin, the distinguished physiologist, Prof. Virchow, remarked to the present writer, "Give my compliments when you return to your eminent countryman Dr. Draper, and say to him that, when my son left home to pursue his studies, the only book I gave him was the 'History of the Intellectual Development of Europe.'"

Thus prepared, Dr. Draper has entered upon a chapter of history never before systematically undertaken. History in relation to science has hitherto been confined almost entirely to its subject-matter. Dr. Draper, on the other hand, considers the progress of science more in its human relations, or as connected with the interests and experiences of humanity. While others detach it from the accompanying circumstances, he views it as dependent upon

them, as implicated with human passions and prejudices, and the influences of race, faith, nationality, states of society, and all the forces of obstruction and acceleration by which the human mind is affected. The most conspicuous and important feature in the history of science he considers to be its long conflict with theological authority. Religion was first in the field, and reigned supreme before science appeared. It put forth supernatural claims to the understanding of Nature, so that the profound ignorance of the natural world had a kind of religious consecration. To inquire was to question received explanations, to doubt pious beliefs, and was therefore impious. In its faint beginnings, therefore, among the pagan Greeks, science was denounced for the same reasons and in almost the same terms that it was recently anathematized by the Vatican Council. To fill in the links of the long-protracted struggle that has intervened, and delineate the stages of the mighty controversy which Dr. Manning declares to be now impending, was the object of Dr. Draper in preparing his work. He has, therefore, not only supplied an obvious want of historic literature, which would have been valuable at any time, but in the present crisis of the great elements, political, religious, and scientific, he has given us a text-book of the subject, by which the experience of the past is made the basis for an intelligent judgment of the present. The problem is undoubtedly immense—too great for any thing but proximate solution, and in a pioneer attempt we are not to expect perfection; but Dr. Draper has done his work ably and courageously, and in a manner worthy of his high reputation and the greatness of the theme. His book will be read with avidity by thousands in both hemispheres, who will gladly acknowledge their indebtedness to it for help and light in the present crisis of the questions it considers.

NORMAL CO-EDUCATION.

In the October MONTHLY we published a letter of Prof. Cochran, from Dr. Clarke's late work, "The Building of a Brain," on the effects of co-education in the Albany Normal School. We have received a suggestive letter from a lady who was connected with the institution at the time, and who says that "the cases of illness or of failing health among the young ladies were sent to me to inquire into and care for;" and she adds that, "to those familiar with the work of the Albany school, at this period, no statistics drawn from its health-roll would count any thing whatever in this discussion." It is mentioned that, "in 1864, when Prof. Cochran left Albany, in a school of over two hundred pupils, there were twenty gentlemen, so that, as far as education is concerned, it would seem that some deference might have been paid to the greatest good of the greatest number." The curriculum is, however, characterized as "oppressive." Our correspondent claims to have investigated the subject, and says that, while "with regard to the facts there is little question, with regard to the causes there is a very important one." Her general view of the case is presented in the following passages from her communication:

"I have reached the conclusion, from my investigations, that no statistics drawn from mixed schools can prove any thing with regard to co-education or identical education, until the two sexes can be placed in those schools upon equal or similar conditions.

"While there are a hundred outside things that militate against a woman's success in such a school, which find no parallel in the conditions of the male pupils, ill health or want of power among the female pupils can prove nothing. In every quarter woman is unfairly weighted for the race; but especially in our normal schools these conditions have reached their climax. For example:

"In 1856 one of the young ladies, whose

failing health warned her of overwork, came to me not more than two months before the time when she should have graduated. Hard as the case seemed, I could only say to her that she must leave school at once. Some facts of her history I obtained from her at that time, but the important points I learned later. She had no home to which she could go. She had been left an orphan at an early age, with a family of brothers and sisters dependent upon her for support. To meet this responsibility she went as a teacher into our district schools. She undertook the hardest positions because they gave a trifle more of pay. She boarded herself, and often went dinnerless to school because the children's bread must not be stinted. She went through mud and snow to her school, with wet feet and scanty clothing, purchasing no rubbers, no warm shawls, because she could not spare the money. She had soon decided that, if she ever lifted those she loved so well from utter poverty, she must fit herself for higher positions, and to this end she began laying aside money that she might attend a normal school.

"So the years passed on, and at last she had saved enough to take her through the two years' course of the normal school at Albany. And now when her classmates were beginning to think of their graduating essays and graduating dresses, her pay-roll was wound up, her summons came, and she turned away from the reward she had sought so tirelessly. The autumn leaves of 1866 fell upon the grave where she found rest for the first time in so many years. This is one of Prof. Cochran's twenty. Another, the same year, was accustomed to take an empty dinner-basket with her to school, and at the hour of lunch to steal away from her companions, that they might not suspect she was too poor to buy a dinner! In my own experience these have been not isolated but representative cases of normal-school invalidism. So familiar have I become with them, that I seem to know beforehand what items I shall obtain in investigating any given case of ill-health. And then the cry arises, 'Co-education does not answer.' It is true we have cases of ill-health among our young ladies which are not to be traced to these causes, but they are so few as hardly to deserve mention. These really make up the bulk of the cases with which we have to deal.

"We have also young gentlemen whose health fails from overwork, but to them the admonition arises in the shape of weak eyes, constant headaches, etc., while with women the more delicately-balanced functions of life are set ajar.

"The young man goes out to teach, and earns sixty dollars per month, while his sister is earning thirty dollars. In half the cases she is the better scholar. The young man goes home to the farm. He is needed in the field, but he is a man—of course he can earn one and a half or two dollars per day; while with his sister they are so glad she has come home to help mother, but it never occurs to any one that she has earned any money. When both return to school, they pay the same price for board, but with him it means that his bed shall be made, his room swept, water brought in, etc., while his washing arrives from the laundry all right every week. But she—the landlady says, 'Of course you will take care of your own room, we always expect our lady-boarders to do that.' She counts over her thirty dollars per month, and says, 'Well, I must do my own washing and ironing if my landlady will allow me.' And the landlady grudgingly consents. Then—'I must make my own calico dresses—I could never afford to pay for that.' To her teacher: 'I wish I could be excused from singing, to-day, I am trying to make a dress.' Or, 'No, I cannot go for a walk, my brother has brought me this whole satchel full of clothes to mend.' In the morning he can easily learn his algebra-lesson while she is arranging on the top of her head the steeple of braids which custom says she must wear. And so the parallel runs on."

From all which, it would seem to be a fair inference that, as the world is at present constituted, co-education is beset with very formidable difficulties. With their inferior strength, their extra burdens, and their more limited pecuniary means, the female students cannot compete with the male students, and in the attempt to do so they break down. The implication is that, in point of fact and practically, there are unequal standards of study to which the two sexes can respectively attain; and, if these standards are to be equalized, either the masculine standard must be lowered, so that the male students will not be pressed to their highest capacity of accomplishment, or the feminine standard must be raised,

to the injury of female health. Our correspondent says that there is little question in regard to the facts, but that "woman is unfairly weighted for the race." Whether unfairly or not, she certainly is so seriously weighted that she cannot win in rivalry with her less-weighted competitor. The real question, then, is, whether this difference is accidental and removable, or whether it is radical and permanent, and belongs to the very constitution of the sexes. Upon this point we hope the MONTHLY will soon have something further to say.

"BACKING OUT."

WE are able to congratulate a number of our newspaper friends upon the happy relief they have experienced through the alleged "backing out" of Prof. Tyndall from the positions taken in his Belfast address. In the preface to that address he said that he had his moods of feeling like other people, but that "the doctrine of material atheism" did not commend itself to him in his hours of clearness and strongest conviction. And in his recent lecture on the "Crystalline and Molecular Forces," a revised copy of which we received from the author and have printed, he says that "the profession of that atheism with which I am sometimes so lightly charged" would be an impossible answer to the question "whether there is no power, being, or thing in the universe whose knowledge of that of which I am so ignorant is greater than mine." That is, in a word, Prof. Tyndall denies that he is an atheist, and this is called "backing out." "Backing out" from what? How can a man back out unless he has first gone in? When or where did Prof. Tyndall ever avow himself an atheist? Whether a man is an atheist or not, he ought to understand himself quite as well as his neighbors. "Oh! but his doctrines imply atheism! his science leads to materialism;" and so it turns out that Prof. Tyndall's atheism is imputed and constructive, something existing in the imaginations of those who worry themselves about other people's religion. It is curious to note how the tactics of those who assume to take charge of the religious concerns of others have been quite reversed in these later times. Formerly the manipulators of thumb-screws aimed to extract from suspected doubters the concession of religious belief — to make them acknowledge that they were Christians; now the policy seems to be to fasten upon them the imputation of disbelief whether they admit it or not. "No matter what you say—you are an atheist, and an atheist you shall be!" But it is said by the newspaper editors, "Prof. Tyndall declared solemnly before the British Association that there are great potencies in matter, and that he even discerns in it 'the promise and potency of every form of life,' which we hold to be the same as abolishing Almighty God, and we are not going to have that done." It is curious how every step of scientific advancement has been met in this way. When the question was one of the simplest physical actions in matter, that of the attraction of its masses for each other by a demonstrative mathematical law, there was the same intense solicitude about what was to become of the Deity. When Newton published the "Principia," even the great Leibnitz sounded the alarm, and affirmed that the English philosopher "had robbed the Deity of some of his most excellent attributes, and had sapped the foundation of natural religion." There is no trouble about *that* now. We can even discern how the operation of this grand and universal law, so far from being derogatory to the Infinite Power by which the universe is governed, must greatly expand and exalt our conception of the administration of Nature. And is it not barely possible that, by enlarging and deepening our view of the po-

tencies of that unfathomable mystery we call matter, we are again heightening our view of the action of the Divine Cause? Vitality is manifested in matter, under the operation of law, just as truly as gravity or cohesion; order is admitted, at any rate, as a Divine institution. Suppose, then, we admit that life is a part of that order, and is ruled as other things around us are ruled, how is that going to vacate the universe of its Divine control? But it is not only not true that Prof. Tyndall, who is certainly the best judge of what he thinks, has ever declared his belief in atheism, but it is not true that his Belfast address implies it; and this his most intelligent and candid Christian critics have again and again acknowledged. He has never taken the position imputed to him even constructively. He has taken no position from which he has retreated. Who, then, *has* "backed out?"—those, of course, who have made the charge, and then withdrawn it.

LITERARY NOTICES.

OUTLINES OF COSMIC PHILOSOPHY, based on the Doctrine of Evolution, with Criticisms on the Positive Philosophy. By JOHN FISKE, M. A., LL. B. In two volumes. Vol. I., 465 pages; Vol. II., 523 pages. Price $6.00. J. R. Osgood & Co.

THIS long-expected work has at last made its appearance, and comes forth with such completeness that those who have been impatient of its delay will be glad that the author has taken the time needed to do justice to a formidable undertaking. In these two solid volumes of nearly a thousand pages, we have an exposition of the most advanced phase of philosophic thought, reduced to a comprehensive system, and presented in a style of rare felicity and attractiveness. Mr. Fiske combines the accomplishments of the scholar with the discipline of the logical thinker, and a large acquaintance with the modern aspects of knowledge, and thus qualified he has taken up the teachings of such men as Comte, Mill, Spencer, Darwin, Bain, Wallace, Lewes, Hamilton, Huxley, and many others, who have figured as leaders of thought in recent years, and, reëxpounding them with his own original additions, has given us a view so clear, comprehensive, and systematic, that its publication becomes an event in the progress of philosophy. But he is far from regarding the contributions of these various philosophers as of equal importance. Mr. Herbert Spencer he considers the colossus of modern thinkers—the peer of Newton, and the man who more than any other is directing the course of inquiry in the present age. His system he adopts with but slight reserve, and remarks in his preface: "Without implying that Mr. Spencer should be held responsible for every thing that is maintained in the following pages, I believe that the system here expounded is essentially his, and that such supplementary illustrations as I have added are quite in harmony with the fundamental principles which he has laid down."

But, while Mr. Fiske has been predominantly influenced in his thinking by the views of Mr. Spencer, and has produced a work which will have great value to the students of that philosopher, as presenting his doctrines in new aspects, and with fresh illustrations and applications, yet it is more than this—it is plainly the product of a course of thinking and study which has gathered materials from other regions of inquiry than those to which the English philosopher has chiefly devoted himself. We have here, not the work of a naturalist or a biologist, but rather of a literary writer, a student of history, philosophy, and theology, who, without presuming to speak with authority on matters of physical science, has still acquired an extensive familiarity with the methods upon which sound scientific conclusions are reached, and has derived from the various departments of natural knowledge no inconsiderable aid in forming and verifying his theory of things. Thus, while following Mr. Spencer's lead throughout the first half of the second or synthetic portion of the work, it is when he arrives at the chapters which deal with society (Part II., Chapters XVIII.–XXII.) that he is evidently most at home, applying, as he does, the generalizations of biology to the

facts of human history, with a skill which brings out some novel results of prime scientific importance. One of those results, regarding the social development of man, is so significant as to justify some fullness of explanation.

The idea which determines the course of inquiry in the chapters referred to was first suggested by Mr. Wallace; and it is that, when the intelligence of an animal has arrived at a certain stage of flexibility, natural selection will begin to prefer mental to physical variations. That is to say, when an animal has become so intelligent that he can meet some of the exigencies of life by varying his intelligent contrivances instead of by incurring some slight physical change, there will then be a tendency for the more flexible intelligences to survive in the struggle for life; and obviously so much more can be done, and so much better done, by securing variations in mental rather than in physical structure, that after a while the amount of mental change will become enormously great and rapid as compared with the amount of physical change. Hence a man may be very much like an ape in physical structure, while his thoughts may be as much higher than the ape's thoughts "as the heavens are higher than the earth."

This is not only a very brilliant but a very useful suggestion. Mr. Wallace, however, has never followed it up, but has left it over for Mr. Fiske, who has applied it with such striking effect to the specific problem of the genesis of man, that he may almost be said to have made it his own. Before the problem of man's vast intellectual and moral superiority, Mr. Wallace retreats discomfited, even after having hit upon the idea which, when thoroughly considered, goes quite half-way toward explaining it; and, like other discomfited inquirers, past and present, he appeals to the supernatural for aid and comfort, when he was bound to go on and overcome the difficulties of the inquiry. Just here the question is taken up in the work before us. Having shown, in accordance with Darwin and Spencer, the general evidences for the evolution of the higher forms of life and intelligence from the lower forms, Mr. Fiske recognizes that the special question of the evolution of man's great mental preëminence requires a special mode of treatment. Some factor has come in which has greatly modified the phenomena with which we have to deal when considering the development of the animal kingdom in general. And this factor, Mr. Fiske maintains, is the existence of social combination, by which man is most conspicuously different from any other animal. The general question of the evolution of society is, therefore, treated preliminary to the question of the origin of man. Having ascended, zoologically and psychologically, from the primitive marine vertebrate to the point of departure of man from the apes, the line is changed, and a descent is made, psychologically and historically, from the higher to the lower phases of human society, with the view of reaching, as nearly as may be, the same point of departure. This inquiry into social evolution gives a formula for human progress, and lands us in the same general theory of primitive society which has been so well illustrated by Maine, Lubbock, and McLennan. The state, in its grandest complications, having been shown to be a development from the primeval clan or family group, very much as a complex organism is developed from the aggregation of amœba-like units, the question comes up, How did permanent family groups arise? Here we come to the very marrow of the problem, for, having passed from a race of primates in which each individual lives for himself, to a race of primates in which the conduct of the individual is determined with reference to the needs of a permanent group of which he is a member, we have then passed from man-like ape to apelike man. Both the intellectual and the ethical supremacy of man have been brought about by social conditions, of which this formation of permanent family groups was the earliest in order. How, then, was this great step taken?

Mr. Fiske gives an entirely new answer to this question, though when once suggested it is so obvious that it seems as if it ought to have occurred spontaneously to every one who has thought upon this subject. A preliminary to the answer is given in the chapter on the "Evolution of Mind," where it is briefly pointed out that the increase of intelligence in an animal, beyond a certain

point, must give rise to a period of infancy, during which the career to be followed by the animal's plastic intelligence is determined by early experiences, but during which, also, the animal is unable to take care of itself. The full comprehension of this point depends on the understanding of as much of Mr. Spencer's psychological doctrine as is expounded in Mr. Fiske's work, and we have not space here to do more than state it. It is, however, familiar to every one that, as a matter of fact, apart from all theory, the growth of intelligence, as we rise in the animal scale, is attended by the appearance of a period of early helplessness, or infancy, which is longest in the highest animals, and is very long in the case of man. It is also a very familiar fact that, where this period of helplessness occurs, there is an accompanying appearance of parental affection and approach toward domesticity in the adult members of the race. These facts give the needed clew to the solution of the problem about the origin of family groups. When once we have have two or three children to take care of, the later ones being born before the elder ones are able to shift for themselves, we have the crude shape of a primeval family group or clan, and have passed from animality which is non-social to animality which is social—that is, to rudimentary humanity.

There appears to be no gap left in this explanation. The intelligence, according to Mr. Wallace's suggestion, is acted upon more and more by natural selection, physical variation taking a subordinate place. By-and-by the growth of intelligence becomes so considerable as to extend beyond the fœtal period into the early years of life. There results a period of helplessness which, when sufficiently prolonged, causes family associations to become permanent, and thus gives rise to society. And it is further observed that this period of helplessness is also a period of plasticity; so that each generation need no longer strictly resemble preceding generations, but may have a slightly different twist given to it in youth, thus making possible a great acceleration of mental progress.

This beautiful generalization, it cannot be denied, throws new and important light upon the obscure and difficult question of the intellectual and social development of man; and, if Mr. Fiske had done nothing more, it would establish his reputation as an original thinker in one of the highest departments of philosophical investigation. But the most interesting part of the work to many readers will, no doubt, be the six chapters of "Corollaries," which discuss the bearings of the doctrine of Evolution upon religion. Those who expect to find in every upholder of development a materialistic atheist, one who—as the *Nation* said of Dr. Büchner—not only expects to die like a brute, but congratulates himself that he is going to die like a brute, will no doubt be somewhat taken aback by the chapter on "Matter and Spirit," in which it is asserted with emphasis that "the latest results of scientific inquiry, whether in the region of objective psychology, or in that of molecular physics, leave the gulf between mind and matter quite as wide as it was judged to be in the time of Descartes. It still remains as true as then, that, between that of which the differential attribute is Thought and that of which the differential attribute is Extension, there can be nothing like identity or similarity."

A notable point of originality is the treatment of religion as the highest psychical phase of that life which consists in the adjustment of inner to outer relations. He regards religion as the manifestation of that striving after complete harmony of psychical life with its requirements, stimulated by the sense of sin or moral shortcoming, for which the analogy is furnished by that striving for mere physical adjustment throughout the animal world, to which the sense of pain is the prompter. This view, as Mr. Fiske maintains, detaches religion from theology, and enables philosophical speculation to proceed to the utmost lengths without fear of detriment to that which men really value in religion, and for the sake of which they cling to the formulas, often absurd or inadequate, in which it is enshrined.

We cordially recommend this valuable work to all who are interested in philosophical questions; and especially to those who are desirous of knowing the latest currents and drifts of speculative inquiry.

REPORT OF A TOUR OF INSPECTION OF EUROPEAN LIGHT-HOUSE ESTABLISHMENTS, MADE IN 1873. By Major GEORGE H. ELLIOT, Corps of Engineers U. S. A., Engineer Secretary of the Light-House Board. Washington: Government Printing-Office, 1874. Pp. 288.

THIS is a very complete account of an inspection of the light-house systems of England and France, made by Major Elliot under instructions from the Light-House Board, and it is a work which will be of great value, technically, to the engineer of light-houses, besides being an extremely interesting recital of the principal features of the European systems. Major Elliot's facilities for observation seem to have been excellent, and it is evident that the time at his disposal was thoroughly utilized. From his very clear report a lucid idea of the principal points of difference between transatlantic systems of lighting and our own is obtained; and the book is profusely illustrated with woodcuts and maps, which serve to explain more fully the leading features of each system.

A very large number of the lights on the North Sea and on the southwest coast of England, as well as several of the more important lights of Ireland, were personally visited and minutely inspected, and full details are furnished with regard to all important points. Minute accounts are given of many of the newest and most approved devices for increasing the effective power of light-houses and light-ships, and the author has not hesitated to propose such changes in our own light-house service as his experience leads him to believe most necessary.

Besides devoting much attention to the subject of illuminating apparatus for coasts, Major Elliot has considered the question of fog and danger signals, and has personally seen many experiments on their relative efficiency. The American steam-siren, now in use on our own coasts as a fog-signal, Major Elliot considers the best device for the purpose; and the Trinity House Board (in charge of light-houses in England) has officially signified its concurrence in this opinion. Some of the changes which he thinks should be made are noted below, and his reasons for advocating these changes seem to be entirely satisfactory:

(*a.*) An increase in the illuminating power of our lamps:

"While the power of our light-house lamps is fixed (i. e., they give only the same amount of light in foggy and thick weather as in fair, in the long twilights of summer as in the darkness of winter), the English oil-lamps are flexible in power, and can be varied by the keepers to suit the varying conditions of the atmosphere. . . . The first-order sea-coast lights of England may be raised from an equivalent of 342 candles (their minimum) to 722 candles, while the maximum power of our first-order sea-coast light is uniformly the equivalent of only 216 candles."

(*b.*) The adoption of mineral oil, instead of animal or vegetable oils:

"It is more cleanly than the lard-oil consumed in our light-houses; it is not injuriously affected by the severest cold; the lamps are more easily lighted, and do not require to be trimmed during the longest nights, thus making commerce less dependent on the watchfulness of the keepers; while its cost is but little more than one-third of that of the latter oils."

(*d.*) The establishment of gas or electric lights at important points on our coast. Major Elliot mentions a light-house of this character in England which gives a condensed beam of light equal to more than 800,000 candles, while our own light-houses can only give the equivalent of a little over 200!

. . . . . .

(*i.*) The adoption of a new method of appointing and promoting light-house keepers:

"The rules of the European light-house establishments in regard to the appointment and promotion of keepers, on whom the utility of light-houses and the safety of life and property so largely depend, are fully described in the report, and the facts are noted that for each light the number of keepers is smaller than in our service; that they are furnished with circulating libraries; that their pride in their profession is stimulated by being furnished with a handsome uniform dress; that they are promoted for merit; that they are educated with care for the management of lights before they are intrusted with the charge of them; that their lives are insured for the benefit of their families, and that they are pensioned when superannuated; none of which obtain in our own service."

(*k.*) The placing of revolving lights on our light-ships. Experience has shown this to be possible, as in Great Britain 30 out of 43 light-ships have revolving lights, while in our own service the only lights so placed are constant.

These recommendations are well worth the consideration they will obtain, for the subject is an important one, not only to light-house boards, but to all those who "go down to the sea in ships," as who does not in these days of steam? E. S. H.

HISTORY OF THE CONFLICT BETWEEN RELIGION AND SCIENCE. By JOHN WILLIAM DRAPER, M. D., LL. D. 373 pages. Price $1.75. D. Appleton & Co. International Scientific Series, No. XII.

THIS second American contribution to the "International Scientific Series" was published December 4th, simultaneously in London and in New York. Translations of it into the Continental languages are in rapid progress, and it will be shortly published in Paris, Leipsic, Milan, and St. Petersburg, so that the views presented by the writer will thus promptly be laid before the leading minds of the civilized world—thanks to the progress of science, which has given us these vast facilities of rapid intercommunication and diffusion of knowledge, and created a liberal public sentiment in all the leading nations by which the expression of advanced opinions is welcomed and appreciated. No more appropriate work could have been done at the present time than to write the history of that long and terrible conflict between the agencies of intolerance and of liberalization which has given rise to modern civilization, and triumphed in that large measure of free opinion which the present age enjoys. In writing such a history, Dr. Draper has done an important service to his time.

Our readers have been already apprised of the nature of Dr. Draper's work, through the statements of the Preface, which appeared in the December MONTHLY; and elsewhere, in the present number, we have spoken of its bearing upon great questions now extensively agitated in the public mind. It only remains to add that it is a book to which no notice or review can do justice, because it requires to be read as a whole, like a novel with a well-sustained plot. It is a book crowded with varied information, presented in historic unity, a monograph illustrating and elucidating a single great idea. One of the incidental characters of the volume is the large amount of interesting information it contains regarding the progress of scientific knowledge. Dr. Draper gives us a succession of vivid pictures of the state of actual science among the early Greeks and the later Romans, at the birth of Christianity, at the epoch of the "Fathers of the Church," in the middle ages, at the period of the rise of modern knowledge, at the time of the Reformation, and in the present century. We know of no work that can compare with this volume in the clearness and fullness of its summary of man's scientific achievements from the birth of knowledge to the present time; and, although these copious facts have been gathered and digested by Dr. Draper for the elucidation of his main subject, they are nevertheless of great value and interest, independent of the use he makes of them. All parties are certain to appreciate and enjoy this valuable portion of Dr. Draper's book.

We are constrained also to call attention to the admirable character of the work as a literary exposition. We often hear about the "dryness," and "repulsiveness," and "hard technicality," and general dullness of scientific writers, and the objection is often too well taken, but it does not apply to Dr. Draper. He writes with a clearness, a simplicity, and a warmth of feeling, that give pleasure to the reader, and he thus gains the chief object of an interesting style. Though a discoverer in science, and one who has spent a large portion of his life in the laboratory, and written many original scientific memoirs, he is not the victim of these pursuits, but has cultivated the graceful in literature and given play to imagination, not only in his beautiful researches, but also in his pages, which are often models of forcible and impressive statement. There are many passages in his writings which, for felicity of expression and sheer eloquence, deserve to be placed among our gems of literature, and the reader will find many such examples in his newly-published volume. We are impelled to call attention

to this feature of the work, because the current notion of the unattractiveness of scientific writers is often made an excuse for neglecting valuable scientific books, and we wish to apprise those who are addicted to this habit that the excuse is not valid in the case of the present work.

CHEMICAL AND GEOLOGICAL ESSAYS. By THOMAS STERRY HUNT, LL. D. 489 pages. Price, $3.00. J. R. Osgood & Co.

AMONG the multitude of compilations and digests upon scientific subjects, which have been latterly put forth on both sides of the Atlantic, by men whose names lend no weight to their work, we welcome this substantial volume by one who has devoted his life to the original and independent study of the subjects with which it deals, and whose high reputation, and the honors he has received from learned societies both at home and abroad, give the best assurance of the valuable character of his labors. Dr. Hunt has done the public an excellent service, in collecting and republishing his chief scientific memoirs. His volume, indeed, was wanted. We have many and excellent text-books of geology and text-books of chemistry, but something like a comprehensive text-book of the relations of these two sciences was a desideratum in our scientific literature which this work will go far toward supplying. For, although it was prepared for no such purpose, and although its papers were produced at different times in the course of a life devoted to research, and of course bear the stamp of the author's views, yet its statements of facts are to be thoroughly trusted, while their theoretic interpretations are so presented as to give us the latest views that science has reached respecting them. The volume is both a representation of the present state of knowledge upon chemical geology and of the growth of that knowledge during the past generation. In no field has there been greater activity of investigation, and, while Dr. Hunt develops the views to which his own studies have led him, he gives us at the same time the opinions entertained by others, or previously accepted, so that the reader is well instructed upon the subject, and is able to form an intelligent judgment for himself. The following passage from his preface will give an idea of the extent of the topics considered. The author's "researches and his conclusions as to the chemistry of the air, the waters, and the earth, in past and present times; the origin of limestones, dolomites, and gypsums, of mineral waters, petroleum, and metalliferous deposits, the generation of silicated minerals, the theory of mechanical and chemical sediments, and the origin of crystalline rocks and vein-stones, including erupted rocks and volcanic products, cover nearly all the more important points in chemical geology. They have, moreover, been by him connected with the hypothesis of a cooling globe, and with certain views of geological dynamics, making together a complete scheme of chemical and physical geology." Since the appearance of Bischoff's treatise on chemical geology, twenty years ago (it was never republished in this country, and if we are not mistaken it is now out of print), we have met with no book that so fully covers the ground as this collection of essays. It will be valuable for reference to the students of economical geology, and interesting to general readers who care to understand any thing about the great agencies of Nature which have produced, and are still carrying on, the changes in the crust of the earth. It will at once take its place in the libraries of scientific men, and should be introduced for reference into all schools where chemical and geological science is studied.

THE PRINCIPLES OF SOCIOLOGY. By HERBERT SPENCER. Part I. Eighty pages. Price, 50 cents. Published quarterly. $2 a year. D. Appleton & Co.

AFTER an interval of some delay, Mr. Spencer resumes the course of his philosophical serial, and has now entered upon what will generally be regarded as its most important part. There has been much impatience, with many, that he has been so slow in reaching the practical and pressing problems of social science which he was expected to handle with originality and power; and readers have complained of the prolonged discussions in biology and physiology which seemed to have nothing more than a speculative importance. But we already begin to see that Mr. Spencer understood what he was about in his thorough elab-

oration of those subjects. It was like the Brooklyn Bridge: the two piers have to be sunk deep and raised high before the useful roadway can be placed. A science of society is impossible, except upon the basis of a science of life and a science of mind which can furnish principles for the interpretation of social facts. Having developed and stated these principles, Mr. Spencer can now use them, and has only to refer his readers back to the places where they have been fully expounded. Because there has been neither a biology nor a psychology that was available, nor any systematic collection of social facts as data for reasoning, there has hitherto been no proper science of sociology; but, having secured these imperative prerequisites with a fullness never before even attempted, Mr. Spencer enters upon the present stage of his philosophical enterprise with a preparation that gives promise of the most valuable results.

We published, some time ago, from advanced sheets, an installment of Mr. Spencer's opening argument on what he terms the original external factors of social phenomena. The first forty pages of the present number are devoted to an enumeration of the social factors of all orders, original and derivative, which enter into the constitution of human societies and influence their development. These are extrinsic, or those which pertain to the conditions of external nature, and intrinsic, or those which pertain to the constitution of man, the social unit. The passages that we have already published are from the former portion of the argument, which considers the climatic conditions favorable to social unfolding. There has formerly been much said about the influence of the aspects and conditions of Nature in determining the character of social life; but, while this is an element of the case of much importance, and not to be neglected, it is still of minor moment as regards evolution, when compared with the internal factors which belong to human nature itself. In Chapter IV., Mr. Spencer passes to the consideration of these internal factors, and devotes Chapter V. to the primitive man in his physical characteristics. Chapter VI. deals with the emotional natures of primitive men as affecting their social relations and possibilities of progress. We publish, in the present number of THE MONTHLY, a few passages from this chapter, which may serve to illustrate the indispensableness of psychology to any thorough scientific treatment of the subject.

We recommend all interested in the study of social questions to subscribe for this work. The terms are so moderate as to be hardly burdensome to any; while the discussion from the foremost thinker of the age, who has devoted his life to this great subject, will give the ripest results of scientific investigation upon problems which are becoming every day of deeper interest to all thoughtful persons.

THE COMMON FROG. By ST. GEORGE MIVART, F. R. S. London: Macmillan & Co. 1874. 12mo, 158 pp. Price $1.00.

THIS is one of Macmillan's "Nature Series," and an excellent little book it is. The author opens with the question, "What is a frog?" and by way of answer gives us not only a clear and instructive account of the structure, varieties, and distribution of that animal, but in defining its position in the animal world tells us a good deal about its near relations, and about zoology generally. Though to many an uninteresting and repulsive creature, the frog is really entitled to great consideration on account of its services to science. Says Mivart: "The frog is the never-failing resource for the physiological experimenter. It would take long, indeed, to tell the sufferings of much-enduring frogs in the cause of science! What frogs can do without their heads? What their legs can do without their bodies? What their arms can do without their head or trunk? What is the effect of the removal of their brains? How they can manage without their eyes and without their ears? What effects result from all kinds of local irritations, from chokings, from poisonings, from mutilations the most varied? These are the questions again and again addressed to the little animal which, perhaps more than any other, deserves the title of the 'Martyr of Science.'" The book abounds with interesting facts concerning the habits of frogs and nearly-related forms; and the whole is written with a clearness and simplicity of style which, without im-

pairing its scientific accuracy, make it easy for the general reader. It would have been improved in this respect, however, had a glossary been appended. A few examples of want of care in the use of classificatory terms, and occasional indications of careless proof-reading, are blemishes that may be corrected in a second edition.

PUBLICATIONS RECEIVED.

Report of the Commissioners of Agriculture for 1872.

Practical and Critical English Grammar. By Noble Butler. Louisville, Ky.: Morton & Co. Pp. 312. Price, $1.00.

Polarization of Light. By W. Spottiswoode, F. R. S. New York: Macmillan. Pp. 130. Price, $1.00.

Organic Chemistry. By W. Marshall Watts. New York: Putnam's Sons. Pp. 130. Price, 75 cents.

Practical Theory of Voussoir Arches. By William Cain, C. E. New York: Van Nostrand. Pp. 118. Price, 50 cents.

The Foes of the Farmers. By A. L. Perry. Nebraska Board of Agriculture. Pp. 20.

Missouri Iron-Ores. By Adolf Schmidt, Ph. D. Jefferson City, Mo.: Regan & Carter. Pp. 16.

Climate of the Glacial Period. By Thos. Belt, F. G. S. Pp. 44.

Habits of Some American Species of Birds. By Thomas G. Gentry. Pp. 16.

Researches in Acoustics. Paper V. By Alfred M. Mayer. Pp. 42.

Drift of Medical Philosophy. By D. A. Gorton, M. D. Philadelphia: Lippincott & Co. Pp. 70.

Supplement to the Calculus of Operations. By John Patterson, A. M. Pp. 8.

Longevity of Brain-Workers. By Geo. M. Beard, M. D. Pp. 16.

National Teachers' Monthly. New York: Barnes & Co. One dollar per year.

Legal Relations of Emotional Insanity. By E. Lloyd Howard, M. D. Pp. 15.

The Analyst: Journal of Pure and Applied Mathematics. Des Moines, Iowa. Two dollars per year (bi-monthly).

MISCELLANY.

Climate of the Glacial Period.—This subject is discussed, in the October number of the *Quarterly Journal of Science*, by Mr. Thomas Belt. The cold of the glacial epoch, he thinks, was caused neither by elevation of the land in high latitudes, nor by the position of the earth due to the eccentricity of its orbit, as suggested by Lyell, Croll, and others; but rather by great obliquity of the ecliptic. If the axis of our globe be as that of Jupiter, the days and nights would be twelve hours each, and there would be no succession of seasons. The hot climate of the equator would become more temperate toward the poles, and no snow could accumulate at the sea-level, except, perhaps, immediately around the poles.

With beginning of obliquity of the sun's path, seasons of heat and cold would succeed each other, and these would become respectively lengthened and intensified as the obliquity increased. The long winters of intense cold would cause great accumulation of snow, which the summer could not melt. A climate is made more severe by presence of ice and snow, as many of the sun's rays of both heat and light are reflected, and the earth is not warmed by them. Thus, whatever tends to increase the area of snow increases the severity of the climate. The growth of the ice-sheet would cause it to extend toward the equator, and the movement of warm currents might be arrested. The heat of their waters, before expended in melting ice in the polar regions, would now produce great evaporation along the margin of the ice-belts, and the source of rainfall be augmented.

The great obliquity of the sun's path, contended for by Mr. Belt, exists in the planet Venus, where the tropics overlap the polar circle, and a similar state of things here would give us the glaciers as they existed in the ice-age. Moreover, a change in its obliquity back until the sun's path was over the equator, would give the climate which produced tropical plants within the polar circle. The fact of their existence demonstrates the presence there of a mild climate—as enormous unmelting

glaciers prove a climate of intense and continued cold.

The cause of change in the sun's path he finds in changes in the distribution of the matter of the earth. He cites the fact of the earth's equatorial protuberance, and says the mass takes the form of an ellipse, and is not circular, as assumed by some mathematicians, and is itself a cause of change, altering the poles of rotation and the sun's path. Moreover, much may be due to former upheavals and depressions of the earth's crust. The increase of polar ice is, according to Mr. Belt, contemporaneous with increase of obliquity of the sun's path, and must diminish the difference between the earth's equatorial and polar diameters. The tendency of this would be to diminish the obliquity of the sun's path, ameliorate climate, and approximate to a uniformity of seasons and of day and night.

The coming of the cold climate, and consequent increase of polar ice, he thinks was gradual and continuous, and he finds no evidence in Scotland, or elsewhere, of interglacial periods of mild climate. Mr. Belt claims that the glaciation of the north and south poles was simultaneous, as the climate north and south of the equator must have been nearly the same.

This accumulation of ice at both poles accounts, in Mr. Belt's opinion, for several phenomena usually attributed to elevation of land. He thinks the level of the ocean must have been lowered not less than 2,000 feet to supply the ice-sheets.

In the ice once formed upon the polar regions, Mr. Belt finds a dynamic agent adequate to important geological changes.

Thus their weight would cause the polar lands to sink until the earth attains its normal form; by their melting, and flowing toward the equator, the equilibrium is disturbed. But the disturbance from this cause is probably very small, "if," as Mr. Belt concludes, "the earth's interior be as cold as space, and movements occur only in its upper strata."

An Ornithological Land-lubber.—Toward the end of last December, the Challenger expedition visited Prince Edward's Islands, situated about 1,100 miles southeast of the Cape of Good Hope. We find in the *Times* the following notes concerning the habits of the albatross, a bird which frequents these islands in enormous numbers: "The whole of the wet, sodden, flat lands of Marion Island, one of the group, were studded with albatrosses, sitting on their nests. The magnificent birds, most of whom were asleep, covered the ground in such numbers that they looked like a flock of sheep scattered over a meadow. The nests were freshly covered with tufts of grass and moss, and stood some two feet above the swampy ground. It was evidently the beginning of the breeding-season, as few eggs were attainable. These splendid birds, weighing 19½ pounds, and measuring 10½ feet from tip to tip of wing, seen to such advantage while in their glory at sea, so evidently at home as they sweep gracefully through the air, are, on land, 'completely at sea.' It appears impossible for them to hover; so, on alighting at the end of a swoop, the momentum of the body continues after their feet have touched the ground, until they literally turn head-over-heels on to their backs, from which inglorious position their efforts to regain their equilibrium are any thing but graceful. While advancing to the nest, the neck is extended and the body lowered, as they waddle along, like a goose. To rise in the air, they are obliged to run, with extended wings, for some 200 yards, over the soaking grass, before they attain sufficient velocity for the air to get under their wings, and allow them to feel themselves again masters of the situation. Once landed, they are powerless to resist attack: a sharp snap of the beak is their only means of offense or defense. In taking their eggs, the readiest way is to push them backward with a stick forced against their breast, which, balanced as they were, on the edge of the raised nest, was easy work, the drop of two feet being just sufficient to send them on to their backs and prevent them rising, until after the prize was captured."

Decomposition of Eggs.—For some time before his death, Dr. Grace-Calvert was engaged, in company with Mr. William Thomson, in investigating the subject of the decomposition of eggs. From these researches,

as now published by Mr. Thomson in the *Chemical News*, it appears that eggs, when the shells are intact, can only be decomposed by one, two, or all of three different agencies. The first of these agencies is *the putrid cell*. This may be developed in the egg, however effectually the shell is protected against spores from without, or the diffusion of gases; it is generated from the yelk. Certain gases have the effect of retarding or preventing its growth, as carbonic dioxide and coal-gas, but it is promoted by oxygen. One egg, which had for 118 days remained in an atmosphere of oxygen, was found to be decomposed entirely by "putrid cell;" the yelk had expanded, and was thoroughly mixed up with the white, and the contents emitted a putrid smell. The atmosphere, once pure oxygen, on analysis showed only a fraction of one per cent. of that gas, while the amount of carbonic dioxide was 95 per cent.

The second agency in decomposition is a vibrio, which in all cases comes from without, and never exists originally in the egg. Whole eggs that remain dry, exposed to the atmosphere for any length of time, are never attacked by this animalcule; but, if the outside of the shell becomes moist, the vibrios floating in the atmosphere fall on it and develop in the contents. The third agency is a fungus, the *Penicilium glaucum*, which exists suspended in the atmosphere. If whole eggs are placed in a constant draught of air, but few will be attacked by this fungus; but, if they are left in a stagnant atmosphere, the floating spores will settle on the shell, and send their long fibres through it into the contents. This fungus cannot grow in an atmosphere of carbonic dioxide, but in oxygen its growth is most luxuriant. In some cases of decomposition by the penicilium the egg was found to appear as if it had been perfectly coagulated by boiling. The filaments of the fungus branch about in immense numbers in all directions, twisting and twining into each other among the contents.

Experiments on the Living Human Brain.—Some experiments, made by Dr. Bartholow, of Cincinnati, on the living human brain, having drawn upon him the sharp censure of sundry professional journals, he has offered an explanation of his conduct in the *British Medical Journal*. "The person on whose brain the experiments were made was," he writes, "hopelessly diseased with a rodent ulcer, which had already invaded the *dura mater*; life could not have lasted much longer in any case. The patient herself consented to have the experiment made. The experiment consisted in applying electricity to the brain, as in Ferrier's researches, and it was believed that fine insulated needles could be introduced without injury, for the following reasons: The brain has been successfully incised to discharge pus. Portions of the brain have been lost without fatal injury to the patient. Then, the faradic current was used, which has no electrolytic action. In the present case it was the ulcer, not the puncture of the needles, that caused death." Dr. Bartholow concludes his letter as follows: "Notwithstanding my sanguine expectations, based on the facts above stated, that small insulated needle-electrodes could be introduced without injury into the cerebral substance, I now know that I was mistaken. To repeat such experiments with the knowledge we now have, that injury will be done by them, would be in the highest degree criminal. I can only now express my regret that facts which I hoped would further, in some slight degree, the progress of knowledge, were obtained at the expense of some injury to the patient."

The Struggle for Existence.—Mr. Buckland recently fought a pitched battle in the Round Pond, Kensington Gardens, with the innumerable hosts of a crustacean parasite that was destroying the fishes. Having learned that there was something wrong at the pond, Mr. Buckland went there to make a reconnoissance, and found, at one point, some little distance from the bank, a dense "cloud of fish." Having waded into the midst of them, he discovered that the supply-pipe, through which fresh water was admitted to the pond, was nearly choked up. The fish wanted fresh water, evidently. He took up with a landing-net one or two of those that were most sickly, and found them literally covered with parasites. Various means were tried for removing the parasites, the most expeditious way being

the use of a stiff brush, with sand. Having thus taken out of the pond, cleaned, and returned again to the water, many hundred fish, it was discovered that the labor was in vain, for the parasites were so numerous that soon the fishes were infested again. The crustaceans plainly were holding their own. Mr. Buckland now cleared away the mud in front of the pipe, so that the fish might have a chance of rubbing off their tormentors against the bottom. He next conceived the idea of spreading a quantity of gravel about the pipe. With the aid of this and an abundant supply of fresh water at a low temperature, the fish were enabled to rid themselves of their parasites easily, and, in the cooler water, the latter did not find the conditions of life so favorable.

A Worm that the Sparrows refuse.—We recently noted the appearance in the public parks and squares of Philadelphia of a caterpillar which threatened to destroy the the trees. The English sparrow had effectually exterminated the measuring-worm in those parks, but showed no disposition to attack this new destroyer of the foliage. At the late meeting of the American Association, Dr. John L. Le Conte described this insect as the larva of the moth *Orgyia leucostigma*. It is a slender caterpillar, covered with stiff yellow-and-black hairs. The sparrow does not attack it, being deterred, probably, by the bristles, by which it is protected. But, fortunately, the nuisance can be abated without the aid of the sparrows. When the caterpillar has attained its full growth on the tree, it crawls to a neighboring wall or fence, and there, fixing its cocoon, undergoes transformation. The remedy against the annoyance is now very simple, viz., by sweeping the cocoons from the walls and fences with stiff brushes, and placing around the trees rings of tin-plate inclined at an angle. This will give the trees immunity, because the insects are not provided with wings for flight.

A New Source of Illuminating Gas.—An oil-bearing shale of considerable thickness, called Kimmeridge coal, or clay, underlies the whole county of Dorset, and is met with in other parts of England. Various attempts have been made to utilize this deposit for the purpose of producing light and heat, but with little success hitherto. Now, however, the Rev. Henry Moule has succeeded in devising a method of producing from it a good, useful gas. The new gas is obtained by the destructive distillation of the shale, the gaseous products being submitted to purification before use. In this latter process, as also at other stages of the manufacture, chalk is used. The gas itself, though not odorless, is by no means so pungent nor so unpleasant as ordinary coal-gas. During combustion no odor is perceptible, and, so far as can at present be ascertained, the products of combustion contain no noxious gases. Besides the gas, a pungent oil is produced, which Mr. Moule believes can be rendered comparatively odorless, and may with advantage be applied to various purposes. The inventor also proposes to utilize the heat-giving properties of shale and chalk for heating, both by means of gas and in a direct manner, his plans having been matured in this respect.

Contagious Ophthalmia.—In English poor-houses and "pauper-schools," contagious ophthalmia has, from the foundation of such institutions, afflicted the inmates. It is produced by unsanitary conditions of life—want of cleanliness, overcrowding, ill-ventilation, etc. It might be supposed that these establishments would have been greatly improved in later times, owing to the increased attention now bestowed on public hygiene; but the contrary is the fact, as we learn from a discourse by Dr. Brudenell Carter. A serious charge is brought by this gentleman against the Poor-Law Board, viz., that during the last few years their unwisdom has developed this malady in workhouses and pauper-schools "in a manner to which previous English experience affords no parallel." The Government has refused to let the truth be seen, but Dr. Carter has been able to obtain, from a private source, a copy of a report made to an official inspector by the medical officer of one of the schools. It states, among other curious matters, that, of 1,062 children in the school in

question, only 182 had escaped ophthalmia; 163 had suffered from one attack of the disease, 151 from two attacks, 110 from three, 75 from four, 54 from five, 58 from six, 22 from seven, 25 from eight, 7 from nine, 11 from ten, and 204 from more than ten attacks. In a considerable proportion of these cases sight would eventually be greatly impaired, and in many it would be wholly lost.

Portuguese Agriculture.—The art of agriculture is in a very primitive state in Portugal, the instruments of husbandry employed being very little different from those in use during Roman times. Two kinds of ploughs are used, both very rude. The harrow, too, is of the rudest construction, having 15 to 20 teeth of iron or wood, set quincunx fashion into a strong, oblong-square wooden frame, with one cross-bar. As a substitute for the roller, the harrow can be reversed, loaded with stones, and drawn sledgewise over the land. The hoe is indispensable in Portuguese field-husbandry; ground can be prepared by it for seeds, or for planting, more quickly than it can be dug by a spade, though it is less completely stirred and turned over. The cart has two low wheels of solid wood, with iron tires, fixed immovably to an axle which revolves with them. The yoke is fixed to the necks of the oxen, or, in some localities, to the horns.

Lightning among a Flock of Geese.—A singular occurrence, which took place on March 16th, in the northern part of Sutter and the southern part of Butte Counties, Cal., is narrated as follows in the *Sutter Banner:* "On that day, just before sunset, a large thunder-cloud came up, apparently from the northeast, accompanied by an unusual amount of chain-lightning. First a small amount of hail fell, and then followed sufficient snow to whiten the ground. As the hail began to fall, and the lightning flashed, thousands of wild-geese, which were in the ponds of shallow water which exist in that locality during very wet winters, suddenly rose up in a great flutter, as if many hunters had discharged a volley among them. They went up and up, apparently to rise above the fearful cloud. It was nearly dark, and those who saw them rise thought no more of it until morning, when they began to find dead geese, and hear of hundreds being picked up by the neighbors. Some 700 were found. One man picked up on his farm all that two horses could haul. Their heads were badly torn, and their bills split into fragments. The portion of the country thus affected was about a mile and a half wide, and reached several miles into Butte County. The terrific lightning in this cloud was witnessed by people on the Honcut, in Yuba County, and in the central portion of Sutter. The thunder was heard at the distance of twenty miles."

Artificial Furs.—A new method of treating fur has been patented in England, by Mr. Joseph Tussaud, one of the proprietors of the well-known wax-work establishment founded by Madame Tussaud. Mr. Tussaud removes the hair or fur from the skin, substituting for the latter an artificial skin. First, the piece of fur to be treated is soaked in lime-water, for the purpose of loosening the hair. Then it is washed in water, and hung up to dry. Next, it is laid on a board, with the hair-side up, and a solution of glue applied, care being taken not to disturb the natural position of the hairs. The glue having dried and become hard, holds the hairs so firmly as to allow the natural skin to be pulled off. An artificial skin is now applied to the roots of the hairs, by pouring over them liquid India-rubber, boiled drying-oils, or other water-proof substances, which, on drying, will form a continuous membrane supporting the hairs. The glue is then removed by steeping the fur in warm water. Furs prepared in this way are moth-proof, and superior to the natural skin for many purposes, such as mats, rugs, etc. After the removal of the hair, or fur, the skins are still available for the manufacture of leather.

Siamese Medicine.—A Siamese manual of medicine contains the following recipe for a poultice to cure snake-bite: "Take the eyes of vultures, crows, and cats, together with three sorts of animal deposits found on trees; mix all these together, then place nine wax-candles on as many floats made of

plantain-stalks, each ornamented with flowers. After this, let the doctor make an offering of nine silver coins, nine handfuls of rice, nine ceri-leaves, and nine betel-nuts, placing a set of each on the several floats, in honor of the teacher of medicine. Then he is to launch the floats into the river, mould his paste composition into slugs, gild the slugs, and apply them to the wound." Another way of treating snake-bites is the use of enchantments for calling the snake which gave the wound to suck the poison out. "For this purpose, fill three bottles with proof-spirits, then let the doctor repeat the form of incantation, drinking one of the bottles of spirits up, while he enchants over it. If the snake does not come, the doctor is to drink a second bottle, proceeding in the same way; and if, on consuming the third bottle, the serpent still declines to appear, the patient must die. But, should the snake present himself, let the doctor take three cowries in his hand, and seven times rehearse a set form of incantation till he has charmed the snake to come to his left side. Then the poison is to be brushed from the wound with a handful of meyon-leaves seven times, and the patient, if he can be got to eat a betel, will recover." Civilized practice, it may be observed, does not stop with three bottles of spirits, but continues the drinking till the snakes appear!

Fossil Remains of the Moa.—According to the *Melbourne Argus*, a number of bones of the *moa* have been discovered near Hamilton, New Zealand. The moa has never been seen alive since about the year 1650. Tradition describes it as a stupid, fat, indolent bird, living in forests and mountain-fastnesses, and feeding on vegetable food. The moa seems to have been extirpated for the sake of its flesh, feathers, and bones. The natives used the bones for making fish-hooks, and the skull was employed as a receptacle for holding tattooing-powder. Captain Hutton, the provincial geologist, has lately visited the locality where the bones were discovered, and ascertained from personal observation that an accumulation of these bones exists, in a tolerable state of preservation, in a swamp about a mile and a half east of Hamilton. Mixed with the moa-bones were found skeletons of the *aptornis*, a large bird, resembling a swan. There are also the bones of some smaller birds, and these will prove of peculiar value, as hitherto paleontological research has not offered much information as to the kind of small birds which were contemporaneous with the moa. It is estimated that about five or six wagon-loads of bones lie in the swamp at Hamilton.

The Pitcher-Plant.—In a paper read at the American Association, Prof. C. V. Riley gives the following description of the pitcher-plant (*Sarracenia*): The leaf of this plant is a trumpet-shaped tube, with an arched lid, covering more or less completely the mouth. The inside is furnished with a perfect *chevaux-de-frise* of retrorse bristles, commencing suddenly about an inch from the base; thence decreasing in size until, about the middle to the mouth, they are so short, dense, and compact, as to form a decurved pubescence, which is perfectly smooth and velvety to the touch, especially as the finger passes downward. Running up the front of the trumpet is a broad wing, with a hardened border, parting at the top and extending around the rim of the pitcher. Along this border, but especially for a short distance within the mouth, and less conspicuously within the lid, there exude drops of a sweetened, viscid fluid, which, as the leaf matures, is replaced by a white, papery, tasteless sediment, or efflorescence, while at the smooth bottom of the pitcher is a limpid fluid, possessing toxic qualities. The insects which perish in this liquid are numerous, and of all orders, but ants are the principal victims. The plant, however, is omnivorous as regards insects, and Prof. Riley has found in the fluid, at the bottom of the pitcher, katydids, locusts, crickets, cockroaches, flies, moths, and even butterflies, in a more or less recognizable condition.

Effects of the Glacial Epoch on the Distribution of Insects.—In a paper entitled "On Allied Species of Noctuidæ inhabiting Europe and America," Buffalo, October, 1874, Mr. Grote says: "For the origin of certain species we shall have to go backward to the Pleistocene, and consider the

identical species as belonging to a former Arctogæal fauna. The action of the steady increase of cold which characterized the gradual inauguration of the Ice period would have been to drive the insects southward and mix the Arctogæal with the then existing 'indigenous' southern species. The summers of the middle Glacial epoch probably afforded no opportunity for the existence of Noctuidæ throughout the Northern States. On the decline of the Glacial epoch, and with a steady increase of warmth (still continuing), the species would progress northward again. We may regard such a species as *Fidonia fimitaria* G. & R., found in Texas, as an outlying colony of *F. fasciolaria* forced southward and retained by local influences, and possibly having submitted to the modification which enables us at this day to separate the two forms. During the Pliocene, the common ancestor of the two forms may have been different from either. During the Pleistocene, Holocene, and Recent periods, we must consider such species as *Hadena arctica* to have preserved their identity, while many may have perished or submitted to modifications, and these latter may be represented by the closely-allied species of the two faunæ. The Glacial epoch may then supersede the 'Atlantis" of those entomologists who looked for a geographical connection in former times to account for the existence of identical or representative species on the two continents."

The Pottery of the Mound-Builders.—Prof. E. T. Cox, having examined a great many specimens of potteries of the ancient mound-builders in the Western States, has never been able to find any evidence of their having been hardened by fire, or even sun-baked. The material employed is a mixture of river-mud and, most generally, pulverized mussel-shells, united in such proportions as to make a cement which hardens in the air, or on being exposed to moisture, like the concrete of the ancient Romans; hence this ancient "pottery" is in fact a sort of artificial stone. In chemical composition it agrees very closely with the concrete made of ordinary cement-stones. These facts lead to the conclusion that the art of manufacturing concrete, or artificial stone, did not originate solely with the ancient Romans, but that it was alike understood by the earliest inhabitants of America. As regards the mechanical processes followed by these ancient artisans, Prof. Cox says: "Though it is my opinion that the so-called pottery of the mound-builders was fashioned by hand, without the use of a lathe, yet I am convinced that the ancient pottery of Peru, and other South American states, was largely made of pieces formed by pressing the cement into moulds, and these pieces were subsequently united together to form the entire vessel. The lines of union are usually covered by a band, or some grotesque image. The numerous tubercles and other raised ornaments, which cover the surfaces of jugs, vases, etc., could only have been formed in this way. I do not, however, find any pottery of the mound-builders that would lead to the belief that their skill went so far as to enable them to mould it in parts, or to fashion it in any other way than by the hands."

A Primitive Fort.—One of the most remarkable works left by the mound-builders is a stone fort in Clarke County, Indiana. As described by Prof. E. T. Cox, this fort stands upon the terminal point of a high ridge, which is washed on its south side by the Ohio River, and on the north by Fourteen-Mile Creek. The point of the ridge is pear-shaped, and the fortification includes from eight to ten acres. The highest point at the stem of the pear is 280 feet above the Ohio, and is only 10 to 20 feet broad, presenting almost a perpendicular wall to the river. A natural wall of Niagara limestone furnishes complete protection against the approach of an enemy at the upper part of the fort, with the exception of a short gap on the creek-side, extending from the upper point southward for about 100 paces. This break in the natural wall is protected by an artificial wall 75 feet in height, made by laying up loose stone, mason-fashion, but without mortar. The base, for 65 feet in height, follows the slope of the hill-side, and then rises 10 feet vertically. Around the southern terminus of the point there is an artificial stone-wall 10 feet high, which connects the two natural walls of Niagara

limestone, thus forming a complete barrier against attack. Inside the wall of masonry are numerous mounds of earth, and within the line of these mounds is a ditch 4 feet deep and 20 feet wide.

A Cheap Substitute for Bells.—Mr. J. A. Judson, C. E., writes us from Dutch Island, near Newport, that for several years past he has used a steel bar in place of a bell, with very satisfactory results. He caused a bar of steel about one inch and a half in diameter to be forged into an equilateral triangle of about three feet on a side, without uniting the two ends, thus forming an instrument similar in all respects except size to the rude musical appliance called the "triangle," used by negro minstrels and sometimes in brass bands. This is suspended from one of its angles by a rope attached to a simple wooden frame, and is struck by hand with an ordinary steel-faced blacksmith's hammer. A cord attached to the triangle and held in the left hand of the ringer prevents its whirling about when struck. If necessary, it may be permanently lashed, without materially interfering with the vibrations, and could then be rung by some stationary mechanical device. "I may have been fortunate," says Mr. Judson, "in finding an especially suitable bar of steel for the purpose, for it is certainly sonorous and powerful, answering all the purposes of an ordinary factory-bell, at merely the cost of so many pounds of steel, and a few hours of skilled labor."

Heat as a Disinfectant.—In the course of some experiments, made with a view to ascertain how far heat may be employed as a means of disinfecting articles of clothing, Dr. Ransom, of Nottingham, found that white wool, cotton, linen, silk and paper, may be heated to 250° Fahr. for three hours without apparent injury, although the wool shows a faint change of color, especially when new. The same may be said of dyed wools and printed cottons, and most dyed silks; but one kind of dyed silk easily turns brown by this heat, and pink silks of some kinds are also faded by it. The same temperature will, if continued for a longer period, slightly change the color of white wool, cotton, silk, paper, and unbleached linen, but will not otherwise injure them. A heat of 295°, continued about three hours, more decidedly singes white wool, and less so unbleached and white cotton and white silk, white paper, and linen both unbleached and white, but does not materially injure their appearance. The same heat, continued for about five hours, singes and injures the appearance of white wool and cotton, unbleached linen, white silk and paper, some colored fabrics of wool, or mixed wool and cotton, or mixed wool and silk. It is noteworthy that the singeing of any fabric depends not alone on the heat used, but also on the time during which it is exposed. In the experiment, the heat was obtained by burning gas with smokeless flame, and conducting the products of combustion, mixed with the heated air, by means of a short horizontal flue, into a cubical chamber through an aperture in its floor, and out of it by a smaller aperture in its roof. Fixed thermometers showed the temperature of the entering and outgoing currents, which represented the maximum and minimum temperatures of the chamber. A self-acting mercurial regulator maintained the temperature of the entering current at any required degree.

The Science of Education.—One of the most important papers read in the Section of Economic Science of the British Association was that by Mrs. Grey on the "Science of Education." The author complained that in Britain there is no adequate or general conception of what education is, and therefore of the magnitude and complexity of the facts on which a science of education, which can never be an exact, but only a mixed and applied science, must be based. We start with a confusion of terms, using education as synonymous with instruction; and the confusion of thought indicated by this misnomer runs through our whole treatment of the subject, theoretical and practical, and is shown in every discussion of the subject. It is surely time that this confusion should be replaced by a scientific conception of the process which should result in the most valuable of all products—human beings developed to the full extent of their natural capacity. What is wanted is, that teachers, like practical navigators,

should be furnished with the principles of a science they have not had to discover for themselves, and with charts to guide their general course, leaving to their individual acumen the adaptations and modifications required by special circumstances. We have such knowledge to guide us in improving our breeds of cattle and our crops: must we remain without it in the infinitely more important business of improving our human crop, of getting out of our human soil all that it can be made to yield for social and individual good? Must every tyro still be allowed to try experiments, not *in corpore vili*, but on the most delicate and precious of materials—the human body and mind, on the most powerful of all forces—human passions and the human will; experiments in which success or failure means virtue or vice, happiness or misery, lives worthy or unworthy, sowing with every action a seed of good or ill, to reproduce itself in an endless series beyond all human ken?

NOTES.

During the summer, the division of the geological and geographical survey of the Territories under the charge of Prof. Powell explored Northeastern, Middle, and Southeastern Utah. In addition to the geographical and geological work, the expedition has collected, according to the *Tribune*, many interesting facts in ethnography. Prof. Powell has found several new ruins of ancient towns in the Colorado Valley, and has collected some specimens of ancient picture-writings, and many stone implements. Prof. Powell, we are told, is now prepared to indicate in his map the position of many scores of these ancient towns or hamlets now found in ruins in the valleys on each side of the Colorado.

Prof. Theodore Gill, of the Smithsonian Institution, and Dr. Elliott Coues, U. S. A., are engaged upon a systematic revision of the mammals of North America. The scientific competence of the authors, as well as their rare opportunities for the inspection of specimens in practically unlimited numbers, is an ample guarantee for the thoroughness of the promised treatise.

Dr. Lyon Playfair, at the recent meeting of the British Social Science Association, quoted Michelet's statement that, for 1,000 years, no one in Europe used the bath, and urged that it was no wonder that the epidemics of the middle ages cut off one-fourth of the population—no wonder that there were a spotted plague, black death, sweating sickness, dancing mania, mewing mania, biting mania, and other terrible epidemics.

In Sonoma County, California, according to the report of the Department of Agriculture, the farmers soak their seed-wheat from eight to twelve hours in a solution of sulphate of copper, in the proportion of six ounces of the salt to 100 pounds of wheat. In this way the "smut," which is a fungoid growth, is killed, and prevented from spreading from diseased to sound grains.

The council of a new college, recently opened in London for the medical education of women, includes the names of the following eminent physicians and physiologists, many of whom are also lecturers in the institution: Charlton Bastian, King, Chambers, Huxley, Hughlings-Jackson, W. L. Playfair, and Burdon-Sanderson.

About forty years ago the Government of France made a costly attempt to introduce the culture of the tea-plant into that country. Three thousand shrubs were imported and planted in various regions of France. Next year the disaster was complete. It is now known that the tea-plant does not give a crop unless with an average temperature reaching 61° Fahr., and a considerable atmospheric moisture in summer. The English Government have not been similarly deceived. Introduced on the slopes of the Himalayas at a height calculated for the suitable heat and moisture, tea now ranks among the sources of wealth of British India. With like success the cinchona is now cultivated in Asia; but botanists and meteorologists were first dispatched to the Andes to determine the conditions of its native growth.

De Candolle proposes a physiological classification of plants based on their relations to heat and moisture. He makes six divisions, viz.: megatherms, which need much heat and moisture; xerophiles, requiring dry heat; mesotherms, moderate heat; microtherms, natives of temperate climates; hekisotherms, natives of high latitudes; finally megistotherms, an exceptional group which require a mean annual temperature of over 30° C. (86° Fahr.).

A French botanist, Cosson, holds that lichens require a very pure air for their development; in fact, he thinks they afford a very delicate natural test of the purity of the atmosphere.

The Smithsonian Institution is soon to publish a memoir by Prof. Simon Newcomb, of the United States Naval Observatory, on "The General Integrals of Planetary Motion."

THE French Government offers a prize of 300,000 francs for the discovery of an efficacious and economical means of destroying the *phyllozera* or of preventing its ravages. A commission, nominated by the Minister of Agriculture and Commerce, will determine the condition of compensation and the award of the prize.

PROF. MARSH is on his way back from his extraordinary expedition to the Mauvaises Terres of Colorado. A *Tribune* telegram, dated Fort Laramie, November 29th, says that the fossil-beds explored by the expedition are of the Miocene age, and rich beyond expectation. Nearly two tons of fossil-bones were collected, all belonging to tropical animals, some as large as elephants, others allied to the camel, rhinoceros, and horse.

PROF. KARL KOCH has shown conclusively that China, and not Babylonia, is the home of the weeping-willow (*Salix Babylonica*). He describes, under the name *Salix elegantissima*, a new species of willow from Japan whose branches are even more markedly pendulous than those of the *Salix Babylonica*. One great advantage of this willow is, that it is not injured by insects.

IN Montgomery, Alabama, according to a *Tribune* correspondent, the negroes form 69 per cent. of the population, yet of the 63 deaths in September, 53 were from the black population—in other words, 69 per cent. of the population furnishes 84 per cent. of the deaths. In October, the blacks furnished 73 per cent.

PROF. MAYER, of Stevens Institute, has invented an instrument for measuring the minutest possible variations of atmospheric pressure. A hollow metallic vessel, with unyielding walls, containing air, has adapted to it an open glass tube. In this tube is a short liquid column. The glass tube is in an horizontal position. The vessel is surrounded with melting ice, which keeps the air inside at a constant temperature. In this condition the liquid in the tube remains stationary if the atmospheric pressure outside remains constant; but any increase of pressure in the atmosphere will cause the liquid in the horizontal glass tube to move toward the vessel. The contrary motion takes place when the atmospheric pressure diminishes. These motions are registered continuously by photography.

EXPERIMENTS made by Prof. Mayer show that solid cylinders of iron elongate on being magnetized, but contract to a corresponding degree in their transverse dimension, so that their volume remains constant. In hollow cylinders, on the other hand, the interior capacity is increased when they are magnetized.

No European grape-vine will thrive anywhere in the United States east of the Rocky Mountains. Prof. Planchon has written the history of the many efforts that have been at different times made to introduce into this country European vines, but the result has been failure in every case. Immigrants from France and Switzerland have repeatedly made the experiment in Kentucky, Indiana, Pennsylvania, Texas, Alabama, and Ohio; but everywhere the *phyllozera* has proved a deadly enemy. West of the Rocky Mountains the *phyllozera* does not occur, and hence California is filled with European vines.

THE barbarous cruelties and needless wastefulness attending the seal-fishery, as now carried on, have received a check from the Newfoundland Legislature, which has passed a law preventing sealing-vessels from leaving port before a certain date, so as to give the seals at least another month after the breeding-season, in which the young may increase in size and value. The present practice is to kill the old seals indiscriminately, leaving the helpless young to perish by thousands. It is hoped that the governments of other countries will follow the example of Newfoundland.

PRESTEL, a German meteorologist, has observed a marked periodicity in the presence of ozone in the atmosphere. It is at its minimum at the end of September, increasing steadily, and reaching its maximum at the vernal equinox, after which it again diminishes.

A WELL-AUTHENTICATED case of death from the sting of a hornet recently occurred in England. A woman was standing in the road near her house, when a hornet flew out from a nest near by and stung her on the right side of the neck. She fainted almost immediately, and expired in a few minutes.

A CORRESPONDENT of the *Gardener's Chronicle* records a curious instance of the power possessed by the mycelium of mushrooms of penetrating bodies. One side of a mushroom-bed was of brick, four and a half inches thick, firmly set in hard lime, so close in the texture that it was impossible to introduce the point of a nail without considerable force. Nevertheless the mycelium found admission, and produced mushrooms of a considerable size on the other side. The wall, in several places, contained porous bricks and these too the mycelium found its way through.

IN former times it was the custom for men of science, on making a discovery, and previous to publishing it in full, to put it in the shape of an anagram, so that in case some other investigator should make the

same discovery later, and publish it, the anagram might show that the writer of it had the prior claim. At present, the usual custom is to send the discovery in a sealed packet to some academy. A correspondent of *Nature*, who signs himself "West," publishes a scientific discovery anagrammatically, as follows:

$$A^8C^3DE^{12}F^4GH^6I^5L^2M^2N^5O^6P$$
$$R^4S^9T^{14}U^6V^2WXY^2.$$

Now, who will be the first to find the key to this anagram?

A CHEMICAL examination of the air along the line of the London Underground Railway has shown that, when trains are frequent, the air is loaded with sulphurous-acid gas; and the authorities are now seeking a remedy for what has long been a serious annoyance to passengers.

THE waters of the Great Salt Lake appear to be rising from year to year. The mountain-streams are steadily enlarging. The humidity of the atmosphere annually increases as the area of cultivation in the valleys becomes greater, and, as a consequence, the evaporation less. Tens of thousands of acres of farming, meadow, and pasture lands have been submerged along the eastern and western shores of the lake.

FRANK BUCKLAND, having counted the eggs in a single sturgeon, found that they numbered 921,600. The total weight of the eggs was 45 pounds. In one ounce there were 1,280 eggs.

THIS being the season for Christmas-trees, attention is called to the fact that the use of red and green wax tapers is highly dangerous, owing to the poisonous nature of the coloring-matters employed. Analysis has shown the presence in green tapers of arsenite of copper (Scheele's green) to the extent of 0.60 per cent., and of sulphide of mercury (vermilion) in red tapers to the extent of 1.93 per cent. Yellow and blue tapers, on the contrary, are pronounced harmless.

DR. COBBOLD states that cases of tapeworm are about twice as frequent among males as among females, the difference being explained, in his opinion, by the more cautious and fastidious habits of the female sex, as contrasted with males, in relation to the ingestion of underdone meat.

THE disappearance of nitrogenous or organic matter from running water where exposed to the air is well known. Mr. A. Winter Blyth has lately shown that water running through closed iron pipes undergoes a similar process of purification, a remarkable difference being observed between the same water before and after it passes through the mains.

"BLUE GRAVEL" is the name given to a rock underlying the gold-bearing alluvium of California and Nevada. Mr. E. Goldsmith, in a communication to the Philadelphia Academy of Sciences, says that this "gravel" is composed of two ingredients, widely differing in age, viz., of pebbles, and a lava by which they are cemented together. Some of these pebbles appear to be derived from slate rock and others from hornblend rock. The lava is extremely brittle. In hardness it is equal to apatite. A few grains of bright-yellow gold are found in it, but how they came there it is not easy to say. Whether the gold came from the pebbles, or was ejected from the volcano, it is impossible to decide.

DR. JOHN L. LE CONTE calls attention to the dangers attending the use of Paris green for destroying noxious insects. It may so poison the soil as to prevent the growth of all vegetation. The National Academy of Sciences has adopted the following resolution on the subject: "That a committee be appointed to investigate and report upon the subject of the use of poisons applied to vegetables or otherwise for the destruction of deleterious insects and other animals, and also the incautious use of poisons in the ornamentation of articles of food, and for decorative purposes generally, such, for instance, as the coloring of paper."

DR. EDWARD SMITH, F.R.S., one of the most eminent physicians of England, died November 16th, aged fifty-six years. His researches on respiration and urea earned for him a fellowship in the Royal Society; his later researches were devoted to the investigation of the subject of dietetics. Dr. Smith experimented upon himself mostly, and thus subjected himself to many severe physical restraints in the interest of science. His published works are numerous, one of the latest being a volume on foods, in the "International Scientific Series."

DR. EDWIN LANKESTER, a voluminous writer on scientific subjects, and Fellow of the Royal Society, died at Margate, England, October 30th, aged sixty years. He began the study of medicine at University College, at the age of twenty, graduated at twenty-three; afterward studied botany under Lindley, and subsequently became lecturer on materia medica and botany at the St. George's School of Medicine. In 1844 he was elected secretary of the Ray Society; in 1845, was made Fellow of the Royal Society; and thereafter, to the end of his life, held successively positions of importance and trust in various scientific bodies, and as an officer of the state. His writings were chiefly on medical subjects and natural history, botany being his favorite branch of study.

FRANCIS HUBER.

(The blind naturalist, celebrated for his discoveries relating to bees.)